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"COLONIAL MONTH"

THE speech made by Mr. Creech Jones, the Colonial Secretary, in moving the second reading of the Colonial Development and Welfare Bill on May 27, dealt with some of the criticisms of Colonial development contained in the fifth report of the Select Committee on Estimates, and he expressed his confidence that a fair balance had been achieved between economic and social expenditure. It was estimated by the Colonial Office and the Economic and Development Council that, of all new monies being put into Colonial development and welfare, at least half is going into directly productive economic activities, a further one-third into the maintenance and expansion of public utilities essential to development and less than one-sixth into social services. The Government had also indicated the importance of encouraging co-operation, community education, voluntary social effort and the development of initiative among the Colonial peoples themselves.

Mr. Creech Jones claimed that under the Act a great range of essential services has been built up which are now performing most useful work as increasing responsibility is being devolved on the Colonial territories and as they themselves come to grips with their own development problems. His claim was not seriously challenged in the debate, although one or two speakers reserved judgment on the Select Committee's comments, particularly about a coherent strategy of economic planning, until the details of the year's working are available. There was also some discussion on the allocation of capital expenditure; but the debate showed a lively appreciation of the difficulties which arise in determining the right *tempo* of development and of the impracticability of observing a firm distinction between expenditure for social and for economic purposes.

The most important part of the Colonial Secretary's speech, however, was that relating to research. The primary purpose of the new Bill is to raise the limit of expenditure on research and inquiry work in any one year from £1,000,000 to £2,500,000. It does not increase the total sum of £120,000,000 available over the period of ten years. Mr. Creech Jones, reviewing the research work already undertaken, said that 319 schemes of research and inquiry have already been adopted, and expenditure up to March 31, 1949, amounted to £1,541,000. Expenditure last year was about £750,000, and if the Bill was approved the Government had plans involving an expenditure of some £1,600,000 in the coming year.

The Colonial Secretary did not discuss the research programmes in detail, although he indicated that 40 per cent of the estimated expenditure was for agriculture, veterinary and forestry work, 13 per cent for fisheries, 10 per cent for medical investigations, 9 per cent for tsetse research, 5 per cent for insecticides and 5 per cent for products research. About 30 per cent of this work would probably be done in East Africa, 20 per cent in West Africa and 15 per cent in the West Indies. It was hoped to increase the supply of technical and professional workers for carrying out these projects, and Mr.

Rees-Williams, replying for the Government, stressed the importance of careful research as a prelude to development. Even in research, he pointed out, it is important, too, that the co-operation of the Colonial peoples should be secured.

The proposals were broadly and generally welcomed in the House of Commons, which recognized not merely the vital necessity of basing Colonial development on such large-scale research but also the importance of associating the Colonial peoples with the research itself. It was asked, however, whether enough use has been made of available surveys of the material resources of the Colonies, and also whether full advantage has been taken of information available elsewhere. In particular, it was suggested that valuable information might be obtainable from the United States in development of the doctrine contained in the fourth point enunciated by President Truman in his recovery programme on January 20.

Mr. Rees-Williams stated that various matters arising under this point are being discussed with the American officials concerned, and that a Colonial attaché in Washington is constantly in touch with American progress. It was afterwards announced (see *Nature*, June 25, p. 986) that three American agricultural scientists are to make a survey of farming conditions in Africa and to advise on the kind of help which the United States could give to farming there under the terms of the Economic Co-operation Act. This survey is the second project for Africa approved under the Economic Recovery Act; the first is an investigation into the control of sleeping sickness and malaria, and this has already begun. Both surveys can make a solid contribution to the development of backward countries, and if the very real help which the United States is thus rendering is to be appreciated fully by the general public, there must be a much clearer understanding of Colonial affairs than has generally been apparent. Despite the meagre attendance which has characterized debates on Colonial affairs in the House of Commons, there is no lack in Parliament, as the debate on May 27 showed, of members who have first-hand knowledge of all aspects of Colonial development and welfare. Scientific men will note the growing appreciation in Great Britain of the importance of research in this field, and the realization that sound schemes must be based on the results of scientific inquiry. There has been evident, also, a welcome appreciation of the importance of technical education, and of the dependence of progress upon our ability to train the Colonial peoples themselves to share in the technical side of the work.

Lord Hailey's "African Survey" is clearly bearing fruit; but it is not only in Parliament that a wider and fuller understanding of Colonial affairs and of what is involved in Colonial welfare and development is desirable. The 'Colonial Month', which was opened by H.M. the King at Church House, Westminster, on June 21, will doubtless contribute to the education of members of Parliament incidentally: its main purpose is the instruction of the people of Britain at large, but more particularly of the citizens of London. For the remainder of the month many agencies are collaborating in London to enable the people of Britain to see some tangible reflexion of what the King described as "the co-operative advance towards freedom under law which is the hallmark of the British Commonwealth", and thus to link them with the peoples, the Colonies, the Trust territories and the Protectorates in a closer fellowship which is based on knowledge and understanding.

It has been made abundantly plain in recent public debates and discussions on such matters as the groundnuts scheme, the Gold Coast riots, and the affairs of Nigeria and Rhodesia, how much progress depends upon mutual understanding and confidence between the white and coloured peoples. The future of the Colonial Empire has to be worked out by the British and the Colonial peoples in association. There is no simple solution of the varied economic, social and political issues involved: they go to the roots of human relations, and no single solution is likely to prove generally valid. Preconceived ideas and a failure to approach the problems with an open mind, as is expected of the scientific worker in approaching his problems, may easily lead to disaster.

The purpose of the 'Colonial Month' is to increase the number of people in Britain who are capable of understanding the arguments of both sides. Few things are more important to that end than the multiplication of personal intercourse between the British and Colonial peoples; and the vital contribution which scientific workers themselves can make to Colonial welfare and development renders it desirable that they should use to the full whatever opportunities the 'Colonial Month' may afford. The introduction of scientific and technical methods into many sides of Colonial life often profoundly affects the primitive and local loyalties on which the cohesion of social life depends. It is important, therefore, that the work of development should be done with the greatest possible respect for and understanding of the old loyalties, and that every endeavour should be made to avoid the erosion of native life running ahead of the reconstruction which may ultimately be possible when Western ideals are understood and a new synthesis can be effected.

There is here a challenge to the most creative minds that can be found, among both the British and the Colonial peoples; but even such minds cannot effectively shape new social or political institutions or inspire new loyalties unless there is full understanding by their fellow citizens, whether of Britain or of the Colonial territories. The 'Colonial Month' may inspire some to dedicate themselves to such a task; but its real purpose is to stimulate the interest that will lead to a clearer understanding of the many complex problems to be faced jointly by the British and Colonial peoples. A keen appreciation of the human issues involved diminishes the risk of misunderstandings being fostered or exploited by those who do not desire the growth of freedom and co-operation in the Colonial world. Even more important, it is a further step towards the informed public opinion and sound judgment on which the functioning of democracy everywhere depends.

GENETICS AND CYTOLOGY

Advances in Genetics

Vol. 2. Edited by M. Demerec. Pp. viii+373. (New York: Academic Press, Inc.; London: H. K. Lewis and Co., Ltd., 1948.) 7.50 dollars.

Essentials of General Cytology

By Dr. R. A. R. Gresson; including 4 Chapters on Plant Cytology, by Helena Heslop Clark. (Edinburgh University Publications: Science and Mathematics, No. 2.) Pp. ix+184. (Edinburgh and London: Oliver and Boyd, Ltd., 1948.) 21*s.* net.

Introduction to Genetics and Cytogenetics

By Herbert Parkes Riley. Pp. xii+596. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1948.) 30*s.* net.

THESE three books attempt to solve the problem of disseminating information in the rapidly changing fields of genetics and cytology. They do so with varying success. "Advances in Genetics" is a notable experiment. The discussion by Mayr on what species mean in Nature is original and should stimulate systematists who have not realized the equally constructive and destructive effects of experimental method. Dahlberg's account of human population deals with more familiar ideas. Sears on wheat and Heston on cancer have given practical and useful summaries. Catcheside on radiations is comprehensive but, it seems, indecisive on fundamentals. Hughes Schrader on the coccids is not quite new enough or genetic enough for such a book. Caspari on cytoplasmic inheritance covers very fully the work on *Epilobium* by Michaelis and Lehmann, and on *Oenothera* by Schwemmle. These are analytically the least final parts of the story, and they remain as confused as ever. Such a volume is of some value to a few workers. If care were taken to secure coherent summaries and critical arguments from the reviewers, it would be of much value to many workers.

The work of Dr. R. A. R. Gresson on cytology has been written by only two authors, but might, indeed, like the "Advances in Genetics", have been the work of seven. The studies of animal and plant cells, of mitochondria and chromosomes, of the cell and of its functions in heredity are a largely disconnected compilation. Indeed, from this account they would appear to have little business with one another or with life in general, and the author seems to be particularly concerned with those bodies, like the Golgi element (as it is now called), the business of which is unknown. In the circumstances, it is not surprising that development and differentiation scarcely make a showing. There are some excellent photographs and diagrams, but who could guess from this book what had happened in cytology in the last thirty years?

H. P. Riley's text-book of genetics gives in thirty chapters a survey of the subject. Apart from *Oenothera* and cytoplasmic inheritance, it is reasonably up to date. Its point of view is close to the earth, practical and often superficial. Like many other American books on genetics, it is copiously illustrated in a way that will appeal to the very young. It is suitable for the middle forms of schools.

It is indeed remarkable that in the United States, where as much good genetic research is carried out as in all the rest of the world together, no searching, profound, and original account of the subject as a whole has been written for a generation. And only one or two attempts have been made. C. D. DARLINGTON

THE STORY OF PHYSICS

Half-Hours with Great Scientists

The Story of Physics. By Dr. Charles G. Fraser. Pp. xx+527. (Toronto: University of Toronto Press; New York: Reinhold Publishing Corporation; London: Oxford University Press, 1948.) 32*s.* 6*d.* net.

"THE present age is sometimes called the Scientific Age. This does not imply that every member of the community is an expert scientist—far from it. It does mean, however, that the labours of the scientists have given the age certain features which influence the life of every citizen to some degree. Accordingly it is desirable that as many as possible should have some understanding of the scientists' work, of their aims, their point of view, and their methods." This quotation forms the first paragraph of the author's preface, and the book itself is a tribute to the skill with which Dr. C. G. Fraser has succeeded in providing a readable survey of mankind's debt to physicists.

The method employed is calculated to arouse genuine interest, and the personal and historical background, introduced naturally—especially by numerous quotations from the literature of science—adds to the value of the work as a record of human achievement. The limitation of this volume to "the Story of Physics" allows scope for considerable detail and variety within its five hundred pages.

Instead of a continuous story of physics as a whole, the author has developed chronologically a number of themes—mechanics, acoustics, optics, thermics, electricity and magnetism. Each theme is appropriately introduced by interesting references to pre-history, ancient and classical science, followed by medieval and modern studies, particular attention being paid to recent developments. This treatment by themes proves effective and gives ample opportunity for including names which in a shorter and more general survey have inevitably to be omitted.

The volume is well illustrated and produced, and provides the general reader with an interesting account of the various branches of physics. Original sources are given as footnotes, and a comprehensive index enhances the value of Dr. Fraser's work as a useful book of reference. H. D. ANTHONY

MALTHUS MODERNIZED

Road to Survival

By William Vogt. Pp. xvi + 335. (London: Victor Gollancz, Ltd., 1949.) 15*s.* net.

"THE world is sick"—not just from war, nor from the physical disfigurations and social derangements which so far, in the twentieth century, have given a turbulence which Mr. William Vogt regards as symptomatic of a gross ecological disbalance of man and his environment. The author is chief of the Conservation Section of the Pan-American Union; his ornithological studies have led him to approach social problems with a broad ecological view, and his travels and investigations have shown him regions of the world in which the varying states of technological development and of environmental equilibrium impose a dangerous disharmony on the whole. His purpose

here is to jolt those who count themselves especially blessed in their ideas of high standards of living towards a realization that economic and political treatments may solve but cannot cure the fundamental ills, and to revalue their concepts of technological advance and social needs.

In his introduction to this book, Mr. Bernard M. Baruch says "It asks more questions than it answers, as any scientific book must". But it boldly states the basic problems as Mr. Vogt sees them; and even if he does repeat his arguments, be pungently critical at times, and perhaps over-emphasize his contentions, yet these are only his methods—he certainly provokes and stimulates.

The general thesis is not new. About 150 years ago, Malthus argued that the multiplication of mouths was outrunning the food resources of his world. Meantime, the world has changed, though it is still finite, and its peoples increase. The pressures of populations on areas and resources are no longer just of local incidence, but now form a complex world problem; of this we are reminded forcibly and frequently by such bodies as the Food and Agriculture Organisation, as well as by Boyd Orr and Russell, whose views range beyond the isolated and domestic fields. Vogt thinks likewise, although his castigation of narrow-mindedness in some of his countrymen does not always conceal a naïve wish that the American standards of life may be preserved.

Vogt considers the problem on the basis of a simple equation, $C = B/E$; the population-carrying capacity of an area is that permitted by the ratio of its "biotic potential" and the "environmental resistance". Modern agricultural developments have not served to raise biotic potentials, but have actually raised the environmental resistance in many areas, for example, by encouraging soil erosion. (In any event, and regarding only the direct climatic control, Ackerman has calculated that some eighteen per cent of the agricultural areas of the world have arid or subhumid climates.)

Policies of balanced agricultural systems, and of "substained yields" in forest areas, are vital requirements. Sensible, ecologically sound schemes of conservation and development are widely needed; against Vogt's standards, the Tennessee Valley Authority is but a poor prototype. The "ecological incompetents" who exploit and deplete land resources deserve to be liquidated rather than to become charges upon public funds, as they do so frequently when their enterprises are subsidized.

The author is, of course, greatly concerned with the social factors that are concealed in his basic equation. He ranges over all continents and times for his examples. The old civilizations of Asia and elsewhere were simple in structure and were ecologically in harmony with their environments. The increasing complexity of Western and New World civilizations has developed increasing population pressures which have crept, and still creep, throughout the world. Vogt quotes Cressey: "Reckless increase [of population] without corresponding technological advance can lead only to chaos". In terms of the basic equation, environmental resistance is raised by high population pressure, so that carrying capacity is lowered; and with this, social standards and levels eventually decline. The Jewish achievements in Palestine, as described by Lowdermilk, are to Vogt a "heartening scene"—but B/E sets the ultimate limits. On the other hand, "Tanganyika Territory enjoys two advantages—a low population and sleeping sickness"; but the application of new technologies is tending to make its environment unstable.

Generally, a decreased need for food is inconceivable for decades; and in any event, the decline in population growth-rates is too slow a process to extend hopes of relief from the pressure of people on food supplies. Time is short—What are immediate, possible solutions of the problem?

"By excessive breeding and abuse of the land mankind has backed itself into an ecological trap." Without voluntary birth control there must be a continually increasing population pressure and a resultant low standard of living. Vogt suggests—almost casually and callously—that in these days the "unchecked spawning" of India, China and other areas has been so encouraged by the trade in their food products, that United States aid to such areas should be conditional upon their applying measures of voluntary birth control, and that contraception programmes should be incorporated along with conservation and food production programmes of the Food and Agriculture Organisation. For, "Conservation is not going to save the world. Nor is control of population," and "A world organisation devoted to search for economic and political solutions that ignores the ecological is as helpless as a bird with one wing".

To the support of his argument, and to aid the more inquisitive reader, Vogt adds liberal documentation, a useful reading list, and an apt index to his powerful and provocative text. But while he severely criticizes the specialism of technicians and the short-sightedness of politicians, he also leaves us with the feeling that, perhaps after all, in his enthusiasm for his own interpretations, he has not been quite wide enough in his review or appreciation of other contributing developments which can affect the attainment of better and sounder use of the available "biotic potential" as well as the control of "environmental resistance".

J. E. Nichols

GRASSLANDS OF LATIN AMERICA

The Grasslands of Latin America

By G. M. Roseveare. (Bulletin 36 of the Commonwealth Bureau of Pastures and Field Crops.) Pp. 291. (Aberystwyth: Commonwealth Agricultural Bureaux, 1948.) 20*s*.

ONE of the chief functions of the Commonwealth Bureau of Pastures and Field Crops has been to collect and index information on the grasslands of the world. Vast tracts of such land, very diverse in character, are found in Latin America, and Miss G. M. Roseveare has carried out the formidable task of bringing together in a single bulletin the data relating to them. From the voluminous nature of the material available, no concise, summarized account can be expected, and as Dr. R. O. Whyte states in his foreword, the reader must be left to weigh up one fact or point of view against another and to make his own decisions. The information, however, has been presented in a well-arranged and readable form, the short historical introduction adding considerably to the general interest of the bulletin.

The five principal chapters, including one on the natural grazings of Corrientes and the Argentine Chaco contributed by Prof. L. R. Parodi, are concerned with a description of the natural grasslands.

Four main types are recognized: good natural grasslands, cool mountain grasslands, semi-arid grazings and the savannahs of hot climates. The good natural grasslands are largely tick-free and are found in temperate zones. They vary widely in nature and management, the lucerne ley, for example, being an outstanding feature of the Argentine pampa, whereas it is exceptional in Uruguay or southern Brazil. Of the cool, mountain grasslands, many are usable in the summer only. Increased attention is being paid to their improvement by the introduction of suitable grasses and legumes, and there seem to be good prospects for the expansion of the wool trade in the Peruvian highlands and Ecuador, where llamas, alpacas and sheep do well. The grazings classed as semi-arid are found in both hot and cold climates. Here the herbage is poor, and the sheep and store cattle derive much of their food from trees and shrubs. Improvement is unlikely unless expensive irrigation schemes could be carried out. The savannahs are confined to the regions with hot climates, alternately excessively dry and excessively wet. They are of the least agricultural value and are very liable to flooding and animal pests and diseases.

The next five chapters deal with special aspects or problems connected with grassland, such as the temporary ley, the utilization of browse plants, soil erosion, animal and plant health, and general management and improvement. Though lucerne is the classic example of a plant successfully introduced for supplementary feeding, cereal leys are a characteristic feature of some regions, and the suitability of other grasses and legumes is being tested. The dangers of soil erosion, which in many regions has assumed serious proportions, are fully realized, and the help of the United States Soil Conservation Service has already been sought. From the concluding chapter it is evident that the Governments of the Latin American countries are fully alive to the need for scientific study in the development of their natural resources, and a spirit of co-operation exists which augurs well for their future.

References naturally form an important feature in a publication of this nature, and nearly nine hundred are supplied. The bulletin also contains a number of maps and photographs, some botanical analyses of pastures and a list of browse plants, and concludes with a special index of more than thirteen hundred genera and species.

K. WARINGTON

MOLECULAR ORBITALS AND ORGANIC REACTIONS

The Electronic Theory of Organic Chemistry

By M. J. S. Dewar. Pp. xi + 324. (Oxford: Clarendon Press; London: Oxford University Press, 1949.) 30*s*. net.

THE advent of a new British book dealing with the electronic mechanisms of organic reactions merits special attention, even apart from Sir Robert Robinson's commendation in a four-page foreword, and the Clarendon Press is to be congratulated in having published one of the most stimulating volumes on modern chemistry.

Dr. M. J. S. Dewar boldly introduces electronic theories in terms of wave-mechanics; and, having represented simple covalencies by wave-functions for molecular orbitals, he explains non-mathematically the differences between the *sp*-orbitals of single bonds and the *p*—*p*, or π-orbitals of double bonds, and develops his theme to conjugated and aromatic systems without using Pauling's conventional 'canonical state' formulæ for resonance systems. He shows that this molecular orbital representation has great advantages, for it can be used to explain in the phraseology of wave-mechanics the true intention of the well-known 'curved arrow' (⌒→) symbolism of Robinson. In this respect Dr. Dewar has rendered organic chemists good service by breaking away from the static approach to chemical reactivity which has been forced on us so much by Wheland and other American writers, and stressing again the essential British point of view—dating from the time of Lapworth—that significant, and predictable, electronic *changes* occur *within* molecules during the course of their reactions.

The main chapters of Dr. Dewar's book deal with examples of organic reactions in a way which so closely follows Sir Robert Robinson's (alas, often unwritten) teaching, that a harsh critic might say that he has done little more than to reproduce Robinson's theories with fresh examples in a new jargon. Actually, so many of the examples deal with newer reactions of current interest and importance that the volume will greatly stimulate organic chemists who already possess a good background of factual knowledge. The book, however, may be confusing to the undergraduate, for he would find in it neither a detailed treatment of many simple reactions of major importance, nor the key references which are essential to anyone who wishes to trace back theories to their originators, or facts to the actual experimental reports.

Dr. Dewar explains away these omissions on grounds of space; but it is only too evident that he has written his book over-hastily. Those conversant with the subject will encounter examples of misquotation of fact and of misrepresentation of ideas of other chemists (for example, in connexion with the benzidine re-arrangement).

The most controversial feature of the whole book is undoubtedly the use of his "*π-bond*" formulation of both structures and reaction processes; but this novel theoretical outlook of the author himself should not be judged too critically until a much larger body of diagnostic factual evidence is available. It is evident, however, that in this book the term "*π-bond*" is used very broadly to denote any structure of a molecule, or transition intermediate, in which easily polarizable *p*—*p* electron-pairs are involved. Viewed in this light, all electromeric changes do undoubtedly involve π-bonds, though one may often question the necessity of introducing a special new symbolism for what may often be a mere transition state of a reaction which includes, at some part, a triangular system of three atomic nuclei and four electrons, two of which are mobile. Molecular re-arrangements, for example, are all explained in terms of *π-bonds*, and here it is a great pity that Dr. Dewar has overlooked the simple and adequate treatment of them given by Hughes and Ingold in 1940 on the basis of their S_N1 and S_N2 reactions, for this provides a clear and straightforward interpretation of both the kinetics and the crucially important stereochemistry of all cases of intramolecular change.

Nevertheless, as food for thought, and for its clearly written, daringly put argument, this book is certainly very well worth reading.

W. A. WATERS

Some British Pioneers of Social Medicine

By Prof. Major Greenwood. (University of London, Heath Clark Lectures 1946, delivered at the London School of Hygiene and Tropical Medicine.) Pp. viii+118. (London, New York and Toronto: Oxford University Press, 1948.) 12*s*. 6*d*. net.

THE administrative machinery of the National Health Service, making possible comprehensive morbidity statistics to supplement information already available from a century of death registration, has naturally revivified interest in medical statistics. An exciting bend in the road is always a good place from which to look at the view behind, and any discipline is happy when it produces so felicitous a chronicler of its past travels as Prof. M. Greenwood.

In his Heath Clark lectures for 1946, now published, besides new essays on Farr, Simon and Chadwick, beginning again to be well known after an interim of historical neglect, he devotes three essays to the antecedent generation of late eighteenth-century physicians who first indicated the trails which the Victorian sanitary reformers established as thoroughfares of knowledge. There are considerable difficulties in visualizing, at this remove, what sort of animal the medical man was before medicine had a laboratory background and before its practitioners were educated to a prescribed pattern. Prof. Greenwood's essay on "Medical Culture at the end of the Eighteenth Century", in particular, is helpful towards the performance of such an exploit of historical insight, if only because it makes the reader eager for detail which cannot be available until more local studies have been made outside the well-documented foci of London and Manchester.

The final essay of the book deals, rather perfunctorily, with Florence Nightingale, whose concern for statistics, unlike the Prince Consort's, did not escape the notice of her official biographer, and with Francis Galton, whose only excuse for being in company with the other subjects of the book would appear to be a share in the author's generous affections.

R. PADLEY

Farmers' Co-operation in Sweden

By Åke Gullander. Pp. ix + 152 + 11 plates. (London: Crosby Lockwood and Son, Ltd., 1948.) 7*s*. 6*d*. net.

THE author has been closely associated with the development of the co-operative movement in Sweden for the last twenty-five years. The period was one of changing economic and social conditions and grave crises in the farming industry. Faced with falling prices, and often at the mercy of middlemen, Swedish farmers turned to co-operation to get them out of their difficulties. The story of their efforts is related with intimate knowledge of the circumstances and many of the leading personalities. Written for British readers, the book opens with a description of typical Swedish farms in different agricultural regions.

Broadly speaking, Sweden is a country of small farms worked by the owner and his family, often with forestry as a sideline. It is a livestock husbandry with the dairy cow as the centre point. Consequently, the processing and marketing of milk products, meat and bacon take the first place in co-operative organisations. The dairy co-operatives, in particular, have increased their membership fourfold in the last twenty-five years, and now have ninety-seven per cent of the farmers on their books. They control practically all milk, both for processing and retail distribution. Co-operative slaughter-houses have expanded from small beginnings to take in about three-quarters of the farmers as members, and are now big enough to influence the market. Co-operative organisations for buying and selling cereals, fertilizers and feeding-stuffs have also made great progress, and it is estimated that they now handle about sixty per cent of farmers' requirements. In addition to these main fields, co-operative enterprise of one sort or another touches most of the activities of the farming community, and also reaches the housewife in the home and provides educational courses for young people. The whole is organised under a central body.

The book is well illustrated and carries statistical data relating to the activities of the various bodies over a series of years. It is written in a personal and, at times, almost anecdotal style. The author ends on a note of solid achievement, the stabilization of farming and the provision of technically efficient and modern processing industries. He regards farmers' self-help through combination as a surer method than government price-fixing, which is at the mercy of political parties.

Gall Midges of Economic Importance

Vol. 4: Gall Midges of Ornamental Plants and Shrubs. By Dr. H. F. Barnes. (Agricultural and Horticultural Series.) Pp. 165+10 plates. (London: Crosby Lockwood and Son, Ltd., 1948.) 15*s*. net.

THE horticulturist whose aim is to grow plants finds himself beset with many difficulties, and sooner or later bewails his lack of knowledge of one or more of the scientific-ologies. It is a welcome event, therefore, when an acknowledged authority in some special field produces a book which, while indispensable to the specialist, is both intelligible and of interest to the layman. This book is of such a nature. To say that this volume maintains the high standard of the three volumes published earlier is indeed high praise; but it is well merited. The grower will be especially grateful for the care with which the symptoms of gall midge attack in many plants are described, and for the attention paid to methods of control. Admirably indexed, and with an extensive bibliography, the 128 pages of text in this book represent such a mine of carefully sifted information that all interested in ornamental plants and their pests will gladly acknowledge their deep indebtedness to Dr. Barnes.

Rocks and Rock Minerals

By Louis V. Pirsson. Third edition, revised by Prof. Adolph Knopf. Pp. vii+349. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1947.) 24*s*. net.

THE third edition of this useful American text-book of macroscopic petrology is similar to the previous edition published nearly a quarter of a century ago. The book has been slightly condensed and the chapters on sedimentary and metamorphic rocks rewritten. Following a short introductory section come three chapters on rock-forming minerals and their determination; the remaining chapters, constituting about two-thirds of the book, are concerned with the general petrology, classification and description of the igneous, sedimentary and metamorphic rocks. The numerous effective plates and figures are practically unchanged in this new edition. The serious amateur and the student of geology in particular should both find much of interest and value in this book.

P. A. S.

GIANT MOLECULES*

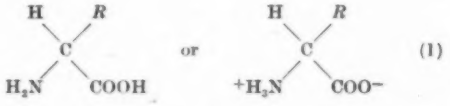
By Sir LAWRENCE BRAGG, O.B.E., F.R.S.

I PROPOSE to deal here particularly with the investigation of the structure of crystalline proteins by X-ray analysis. It is a formidable task. X-ray analysis is being extended to ever more complex molecules; but in the proteins we are confronted with a degree of complexity several orders higher than that of the most complex organic molecules which have hitherto been determined with success. The following table of molecular weights indicates the nature of the problem:

Naphthalene	128	Hæmoglobin	66,700
Penicillin	320	Tobacco seed globulin	300,000
Insulin	12,000	Hæmocyanin (whelk)	6,800,000
Myoglobin	17,000	Tomato bushy stunt virus	10,000,000
Pepsin	37,000		

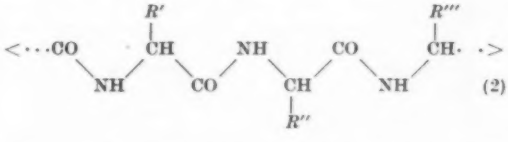
Naphthalene was the first organic molecule to be analysed, by W. H. Bragg some twenty-five years ago. Penicillin is one of the latest triumphs of X-ray analysis, described in a recent publication by Crowfoot, Bunn, Rogers-Low and Turner-Jones. Insulin, which is one of the simplest of proteins, has a molecular weight nearly forty times as great, and from it we pass to the vast molecules of such bodies as the viruses. All these substances yield highly perfect crystals, and give X-ray diffraction photographs, as was first shown by Bernal, which show a regularity of structure down to atomic dimensions. It is the task of X-ray analysis to try to interpret these photographs. One can measure the intensities of many thousands of diffracted beams from each crystal; it is like a story written in a cipher for which we are seeking the key.

The proteins are built, as was first shown by Emil Fischer in 1906, of long chains or rings of amino-acid residues. A typical amino-acid has a formula



(1)

when R represents a univalent side-chain of a kind which characterizes that particular amino-acid. The acid group of one amino-acid can be linked to the basic group of another, with the loss of water, so as to produce a chain of residues in which the different side-chains R are like differently coloured beads strung on a necklace, the 'peptide chain':



(2)

There are some twenty-three types of known amino-acid, varying in complexity from glycine, in which R is a hydrogen atom, to phenylalanine, which contains a benzene ring, or tryptophane, which has linked five- and six-membered rings. Most contain only carbon, oxygen, nitrogen and hydrogen; a few have other elements such as sulphur. In most of them the side-chain R is neutral, as in alanine, $—CH_3$, valine, $—CH(CH_3)_2$, phenylalanine, $—CH_2.C_6H_5$. It may be basic as in lysine, $—CH_2.CH_2.CH_2.CH_2(NH_2)$, or acidic as in aspartic acid, $—CH_2.COOH$. Cystine is a double-ended amino-acid, $—CH_2—S—S—CH_2—$, which can form a bridging link between one chain and another. The analysis of the amino-acid residues in a given protein is a lengthy and difficult procedure, but several have been analysed with a fair degree of completeness. Insulin (molecular weight 12,000), for example, consists, according to Chibnall and Sanger, of 106 residues, in four chains, bound together by six disulphide bridges of cystine. Myoglobin (17,000) has about 140 residues, and hæmoglobin (67,000) has about 540. If we compare the twenty-three types of residue to the letters of the alphabet, the string of residues in myoglobin is like a short statement in some twenty or thirty words, and the nature of hæmoglobin is described by a brief paragraph of about ten sentences. For some reason as yet not understood, Nature has chosen this simple way of building the structures of the molecules in the protoplasm of animals and plants. The complex and specific functions which the molecules are called upon to perform are achieved, not by building any highly complex organic structure, but by stringing these relatively simple groups in different orders and numbers, just as the same few letters of the alphabet can be used to represent Milton's "Lycidas" or a page of the telephone directory.

Certain features of protein structure deserve special mention.

(*a*) Nearly all known amino-acids occur in nearly all known proteins.

(*b*) The mean molecular weight of the residues is much the same in all proteins, lying between 110 and 120. Since the molecular weight of the atoms in the 'backbone' or 'chain' CO.CH.NH is 56, one half the molecular weight of a protein is in its chains and one half in the side-groups.

(*c*) It is nearly certain that all the naturally occurring amino-acids have the same steric configuration around the central carbon atom shown in (1). Since four different groups are attached tetrahedrally to this carbon atom, the compound can exist in dextro- or lævo-forms which are mirror images of each other, being related as a right hand is to a left hand. All amino-acids are of the lævo type, except, of course, glycine, in which R is also a hydrogen atom and there is no distinction between the right- and left-handed forms. It must have been a mere matter of chance that all forms of life started with this same left-handed thread running through them; a world passed through Alice's Looking Glass would work just as well, but some toss of the coin came up tails and decided the future form of all living matter.

(*d*) The crystalline structures of several simple amino-acids or dipeptides composed of two residues

* Evening Discourse at the Royal Institution, delivered on April 27.

linked together have been completely determined by X-rays (for example, glycine by Corey and Albrecht). They show two interesting features. They obey rather exactly the expected distances between atoms and bond-angles found in other organic compounds where strong distorting forces are absent. Huggins has given the following summary of data for an element

$$\begin{matrix} & H & R & O \\ —N— & C_1 & —C_2— \\ & H & & \end{matrix}$$

gleaned from several structures :

$$\begin{matrix} N \text{ to } C_1,\ 1{\cdot}41 \text{ A.}; & C_1 \text{ to } C_2,\ 1{\cdot}52 \text{ A.}; \\ C_2 \text{ to O},\ 1{\cdot}25 \text{ A.}; & C_2 \text{ to N},\ 1{\cdot}33 \text{ A.} \\ \text{Angle } NC_1C_2,\ 112°; & \text{angle } C_1C_2N,\ 118°; \\ & \text{angle } C_2NC_1,\ 118°. \end{matrix} \qquad (3)$$

Secondly, the structures all contain numerous hydrogen bonds between a nitrogen and oxygen atom, N—H—O. This bond appears to be of decisive importance in deciding the form of the structure, and is 2·65 A. in length. Such data are important as a guide in constructing possible models for an extended polypeptide chain.

The difficulties of applying X-ray analysis to such a complex structure as a protein may well seem insuperable at first sight. It is not possible to proceed directly from observation of diffraction to determination of structure except in very simple cases. The X-ray diffraction picture by itself is not sufficient to determine the structure; it can only be used in conjunction with other information. In the case of molecules of moderate size, this information consists in the knowledge that the unit cell contains a limited number of known atoms, and that these atoms are tied together by bonds the lengths and relative inclinations of which can be very closely anticipated from previous determinations of similar chemical combinations. It is not impossible to try a number of likely configurations, and see if one of them explains the X-ray data. But a molecule of a protein such as hæmoglobin contains 8,000 atoms, and methods of trial and error are inconceivable.

There exists, however, a method of representing the X-ray measurements which gives direct and unequivocal information about the structure, known to the crystallographer as a Patterson synthesis or vector map. The observations of intensity of diffraction are used as coefficients of a Fourier term in a series

$$\sum_h \sum_k \sum_l I_{hkl} \cos 2\pi(hx + ky + lz), \qquad (4)$$

where I_{hkl} is the square of the amplitude for a diffracted spot of order (hkl), and xyz are the co-ordinates of each point in the unit cell of the structure. The result is called a vector map. Suppose there is an atom a at $x_1y_1z_1$ and another atom b at $x_2y_2z_2$, in the crystal pattern. The vector map will then have a peak or lump of density at the point $x_1—x_2$, $y_1—y_2$, $z_1—z_2$, which is arrived at by drawing a 'vector' (that is, a line of given length and direction) from the origin equal and parallel to the vector from a to b. In other words, the vector map cannot tell us where a and b are in the crystal, but it does indicate how they lie with respect to each other. Further, the magnitude of the peak is proportional to the product of the masses at a and b. Fig. 1 illustrates the principle. It would be out of place to go into the derivation of the vector map here, though it follows very simply from the principles of optical interference ; but it is important to understand its nature, because it plays a large part in X-ray analysis. We have gained this definite information, however, by paying a heavy price, because it will easily be seen how very complicated the vector map becomes. If there are n atoms in the structure, n^2 vectors can be drawn between them, and all these are superimposed in the vector map.

A common device for analysing organic molecules of reasonable size helps to surmount this difficulty. A heavy atom such as bromine or iodine is attached to the molecule. The corresponding vectors between the heavy atoms then stand out prominently in the vector map, and can generally be recognized, as they are few in number and, being proportional to the product of the masses, they are very large. It is not hard to deduce where the iodine or bromine atoms must be in the crystal in order to give such vectors, and once they are pinned down it is considerably easier to discover where the lighter atoms are. We have, as it were, stained certain characteristic points of the molecule, much as a microscopist stains a nucleus in a cell. But the molecule of hæmoglobin contains more than 8,000 atoms, and its vector map has some seventy million superimposed peaks. No attached heavy atom could stand out in such a crowd.

There is, however, a ray of hope, provided by the polypeptide chains. Suppose the chains are arranged in a regular way, for example, like a series of parallel rods in the molecule. Many of the vectors will run from one atom to another in the same chain, and when these are drawn in the vector map, they will give a long rod of high density through the origin, and parallel to all the rods in the crystal. Similarly, the vectors from atoms in one chain to those in another will form another rod, parallel to the first, and at an appropriate distance from it.

The situation is shown diagrammatically in Fig. 1. Intra-chain vectors have been drawn as dotted lines from two atoms to their neighbours in the chain, and, of course, similar ones can be drawn from every atom in the chain. All these vectors will be crowded into the region A in the vector map. Similar vectors are shown as light lines from one chain to the next, and they all end in the regions B. If we find a dense ridge running through the origin of the vector map in a certain direction, it is reasonable to deduce that

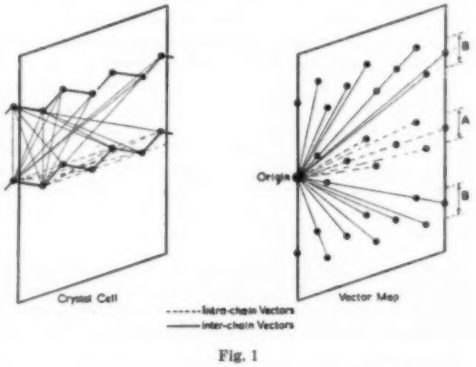


Fig. 1

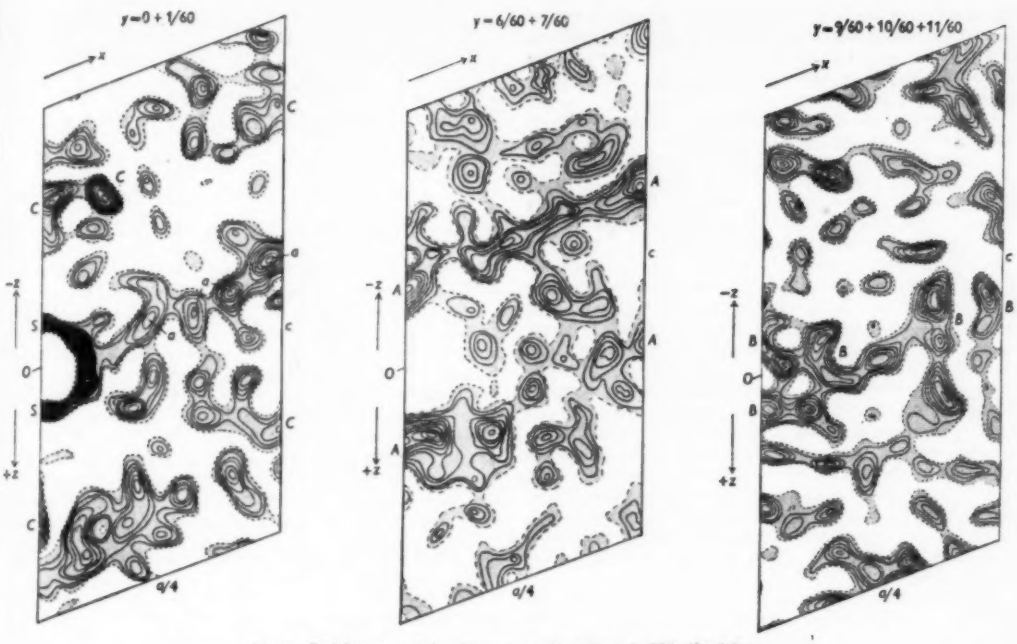


Fig. 2. Scale 1 cm. = 7 A. From *Proc. Roy Soc.*, A, 195, 474 (1949)

somewhere in the unit cell there are chains of atoms running in this direction; and if, in addition, we find parallel rods in other parts of the vector map, they give us a hint as to how the rods are packed together in the crystal.

Certain vector maps obtained by Perutz in studying crystalline hæmoglobin from horse-blood indicated the existence of such parallel rods, and it was therefore decided to make a complete three-dimensional Patterson synthesis of hæmoglobin. The principle is simple. At each point, x, y, z in the unit cell, we form expressions such as (4) for all the diffracted intensities I_{hkl} and add them, and the sum gives us the Patterson density at the point xyz. But consider the magnitude of the task. Perutz had measured some 28,000 diffracted spots given by the crystal, representing the message in cipher which has to be interpreted. In order to get a vector map with sufficient detail, it is necessary to calculate the density at intervals of $a/120$, $b/60$ and $c/60$. The total number of terms such as (4) which are required is therefore $28{,}000 \times 120 \times 60 \times 60$, or $1{\cdot}21 \times 10^{10}$ terms. Of course, the analysis does not take such a formidable form in practice, as various devices can be used which immensely shorten the labour. Even with them, the measurement of the diffracted spots and the computations for this one crystal took some four years, and the final summations were carried out with a Hollerith punched-card machine by the Scientific Computing Service, Ltd. When the project was commenced, it was by no means certain that the results would justify the effort, but fortunately this appears to be the case.

A sample of the results is shown in Fig. 2, which represents cross-sections of the vector map. The crystal cell of hæmoglobin is monoclinic, and in these pictures the a-axis slants from left to right, the b-axis is perpendicular to the plane of the diagram, and the c-axis is vertical. In the left-hand figure we have a cut through the origin O, which is half-way up the left-hand side. The density is represented by contour lines. There is an obvious ridge through the origin running parallel to the a-axis, with peaks on it at intervals of about 5 A., and there are rather less well-defined ridges above and below it. The central figure is a cut about one-tenth the way up the cell in the b direction, and two more ridges are to be seen. Higher up in the diagram (the right-hand figure) there is another ridge above the one through

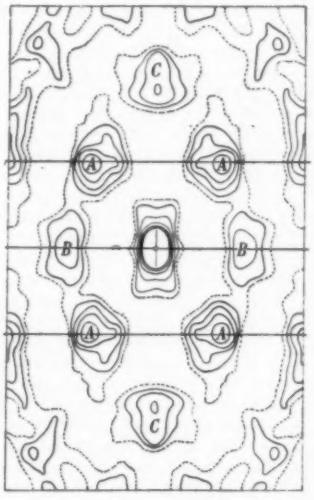


Fig. 3. Scale 1 cm. = 7 A. From *Proc. Roy Soc.*, A, 195, 474 (1949)

the origin. Fig. 3 is a projection of these ridges looking along the *a*-axis so that they are seen end-on, in which the ridge through the origin is now at the centre of the figure and we can see the other ridges spaced round it.

To summarize, Perutz's results indicate that in hæmoglobin the polypeptide chains run parallel to the *a*-axis of the crystal, and that they are stacked about 10·5 A. units apart like a series of rods in approximately close-packed array. Further, the series of peaks in each chain about 5 A. apart indicates that there is a repeat distance in the chains of 5 A., producing many vectors of multiples of this distance along the chains. From this we can deduce a further important point. If the chains have this spacing and repeat distance, the density of the crystal tells us what mass is associated with each repeat, and it turns out to be very closely the average mass of three amino-acid residues. Now three residues in a chain stretched to the utmost as in (2) would occupy 10 A., so the polypeptide chain must be folded or coiled up in some way. Again, the N—H—O bond, which is only 2·65 A. in length, cannot stretch from one chain to the next, and we have seen how important these bonds are. They must presumably be between atoms of the same chain, and it is probably these bonds which are holding the chain in its coiled or folded form.

This evidence confirms certain deductions made by Astbury from the very diffuse pictures given by wool and other forms of keratin, which is a 'denatured' fibrous protein. He has deduced that *a*-keratin is a folded polypeptide chain with repeats of three residues at distances of about 5 A. units.

The question might well be asked: What justification have we for thinking that the vectors in the chains will stand out prominently, when there are also all the vectors between the chains and side-groups, and from atoms in one side-group to atoms in another? Would we not expect the vector map to be a completely confused jumble of peaks? It must be remembered that one half the atoms are in the chains. Further, if these chains really are approximately rod-like and parallel, there should be a very great concentration of atoms around their central axes when one looks along them. As an example, let us take what is perhaps the simplest possible model for a chain of three repeats every five Ångström units, and suppose it to be a spiral with three *R* groups attached to each turn; the bond-lengths and angles then confine the spiral to a radius of about 1·5 A. The average side-chain has about four atoms in it, and leucine (for which *R* is $—CH_2.CH(CH_3)_2$) may be taken as typical. Fig. 4 shows in a very idealized way the appearance of the structure when looking along the chains. For a reason explained below, the chains have been represented as being 9·5 A. apart horizontally and 14 A. apart vertically. The circles enclose the 'chain' atoms, twelve to each repeat, and three leucine groups are attached to each turn with four atoms per group (no attempt has been made to represent the actual positions of these atoms; the diagram is merely intended to show their concentration). The outline of the leucine group is drawn with a van der Waals radius suitable to the packing of groups not attached to each other by bonds. The density in the circles, where the atoms are all linked by covalent bonds, is about ten times as great as that in the spaces between them. It is reasonable to expect that these highly concentrated masses will stand out in a Patterson projection, both as regards the short vectors inside each chain and the vectors from one chain to the next.

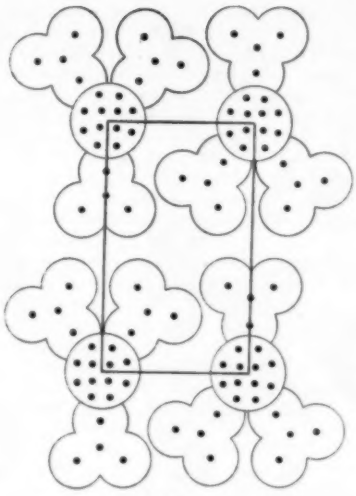


Fig. 4

The spacings of the chains in Fig. 4 are based on a recent examination of the structure of myoglobin by Kendrew, which is being published shortly. The structure is considerably simpler than that of hæmoglobin, the molecule being about one quarter the size. Patterson projections on the principal planes show chains very like those in hæmoglobin, and with similar repeat distances of 5 A. These chains lie in planes parallel to the *b*-face, and are in the direction [201] of the crystal. A Patterson projection on a plane perpendicular to the chains has turned out to be extremely simple and very suggestive. It indicates an arrangement of the chains very much like that of Fig. 4, the chains being 9·5 A. apart horizontally, and lying in sheets 14 A. apart in the vertical *b* direction. It further indicates that the chains are not directly above each other in the *b* direction as shown in Fig. 4, but slightly staggered. The fact that the side-groups clearly do not fill all the space in Fig. 4 is, of course, accounted for by the necessity of finding space for the water associated with each molecule. Reference must be made to the forthcoming paper for a complete description, but it may be said here that the myoglobin analysis has given us greater confidence in the validity of the above conclusions, and in particular that it gives us a first approach to a picture of the arrangement of the chains in this protein.

All this work on the X-ray analysis of the proteins is still of a highly speculative character. One must be prepared to abandon without hesitation any proposed model, however attractive it may appear, if further evidence indicates that it is not valid. We are like a climber, striving to conquer a most difficult pitch, and grateful for the slenderest cracks and projections which seem to offer a possible hold for hand or foot. The results obtained so far may seem meagre, but a glittering prize draws us on. There must be some very deep and fundamental reason why Nature has chosen the polypeptide chain as the building principle for all forms of living matter, a reason which should become clear if we can solve the mystery of the structure of the protein molecule.

ORIENTATION AND METHODS OF COMMUNICATION OF THE HONEY BEE AND ITS SENSITIVITY TO THE POLARIZATION OF THE LIGHT

By Dr. W. H. THORPE
Department of Zoology, Cambridge

PROBABLY many biologists are by now acquainted with at least the outline of the very remarkable work on the dances of the honey bee published by Prof. K. von Frisch in 1946 [1,2,3]. Since then, two other papers[4,5] have appeared which have carried the story a great deal further, and it now seems opportune to consider the astonishing picture thus provided of the methods of communication among worker bees and its far-reaching implications as to the capabilities of a bee's sense organs and brain. The zoologist may, indeed, be pardoned if at first he feels sceptical—in spite of the immense detail and thoroughness of the investigation and even though it comes from one of the most eminent living workers in these fields of study. Indeed, one experimental zoologist expressed himself to the writer as almost "passionately unwilling" to accept such conclusions, and probably many others feel the same—for the implications are certainly revolutionary.

Through the kindness and hospitality of Prof. von Frisch, I was able, during a visit to St. Gilgen, Austria (September 27–29, 1948), to perform with him and for myself at his home at Brunnwinkl (which is also the field station of the Zoological Institute of the University of Graz) 'repeats' of certain of the most crucial experiments. Brunnwinkl is particularly well situated for this work in that commercial bee-keeping is practically non-existent there. It would be difficult, if not impossible, to repeat the work in an area where any hives other than those controlled by the investigator were present. My observations covered all the main phases of the work, and I was able to make my own estimates of the efficiency of the indications of distance and direction of food sources given by the returning foragers to their associates. This memorable experience, for which I owe a great debt of gratitude to Prof. von Frisch, enabled me to resolve to my own satisfaction some of those doubts and difficulties that come to mind on first reading the work, and convinced me of the soundness of the conclusions as a whole.

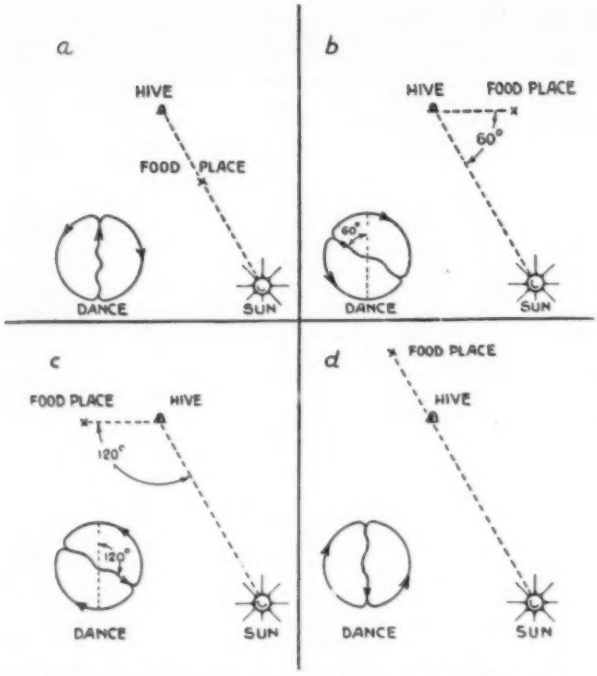
For the benefit of those who have not read von Frisch's papers of 1946 it may be advisable first to describe the main conclusions. When a worker bee discovers a rich (natural or artificial) source of nectar or pollen, she informs the other inmates of the hive of her find by performing a dance on the comb after her return. Bees which are nearby follow her in the dance, become excited and then apparently fly out to search for the food indicated. Quite early in the work it was noticed that there were two types of dance, the 'round dance' and the 'waggle dance', the latter consisting of a very broad figure-of-eight, during the transverse straight run (the 'waggle run') of which the bee waggles her abdomen from side to side at a constant rate.

If the food source is not more than 50–100 metres from the hive, the round dance is performed. This is merely a signal to the other bees to go out and search around the hive for a food source of the same odour as that adhering to the body of the dancer. With increasing distance of the food source there is a gradual modification in the type of dance performed, until at more than 100 metres it becomes the characteristic waggle dance. The number of complete waggle dances in a unit of time decreases with increasing distance of the food source. This inverse relationship is so constant that, by timing the dance with the aid of a stop-watch, one can estimate accurately the distance of the food source from which the dancer brings her burden, and it is clear (refs. 1, 2, Fig. 7) that this dance gives an effective and reliable indication to the other bees of distances between 100 metres and 1,500 metres: at 100 metres there being an average of 10 waggle runs per 15 sec., which drops steadily to an average of 4·5 at 1,500 metres. Further observations described in a later paper[4] show that the waggle dance continues to give an accurate indication of the distance of food source up to 6 kilometres from the hive, the rates at this extreme distance fitting perfectly on to the asymptotic curve obtained for shorter distances. The dance, however, is not effective for *recruitment* of new bees to a food source beyond 5½ km.

The dancing bee also indicates the *direction* of the food source by means of the waggle dance. It must be borne in mind that these dances are normally performed on the vertical surface of the combs inside the hive. Under these conditions, the direction of the waggle run of the dance indicates the direction of the food source in relation to the position of the sun, which is represented by the vertical direction on the comb. This will be clear from the diagram, no doubt already familiar, on p. 12. Thus we see that a waggle run upwards indicates that the food source lies in the direction of the sun. A waggle run downwards shows that the feeding place is in the opposite direction. A waggle run to the right means that the food source is to be found at the right of the sun and at such an angle to the sun by which the waggle run deviates from the vertical; similarly, a waggle run to the left indicates a feeding place at a corresponding angle to the left of the sun.

Thus the complete waggle dance indicates both direction and distance of a food source, and constitutes for the colony of bees an extraordinarily efficient method of harvesting as rapidly as possible a new and abundant source of food. The dance is only performed when a worker has discovered, or is foraging at, a particularly rich source of supply. Each performance of the dance on the comb results in a number of other bees setting out and finding that particular food source. If the supply is still rich when the newcomers reach it, they also dance on the combs on their return, and so a numerous band of foraging workers is quickly recruited for work at a rich source of supply. As soon as the source begins to fail the returning workers cease to dance, although they themselves continue exploiting that source as long as an appreciable yield is being obtained. The result is that any new source of food is rapidly and fully utilized by the colony without any undue waste of time and energy.

The performance of the waggle dance on the vertical comb is so remarkable that we are forced to ask ourselves whether, apart from human faculties, there is anything comparable known in the animal kingdom; for I think it may be said that the performance of the worker hive bee is essentially an elementary form of map-making and map-reading, a symbolic activity in which the direction of action of gravity is a symbol of the direction of incidence of



Four examples of indication of direction. The sun is to the south-east of the hive. The diagram in each lower left-hand corner shows schematically the direction of the waggle dance for a given position of the feeding place. From *Bulletin of Animal Behaviour*, **1**, No. 5, redrawn from *Experientia*, **2**, 401 (1946)

the sun's rays. We can assume that the main orienting stimulus when the bee is on the vertical comb inside the dark hive is the pull of gravity on the body, presumably perceived by the proprioceptive sense organs at the limb and abdominal articulations. It is astonishing enough to find that there is an inherent instinctive association of these two stimuli so that one replaces the other according to whether the bee is inside or outside the hive. But this alone does not carry us very far, and we seem forced back to the conclusion that there must be an inherent recognition of the characteristic movement pattern of the waggle run as equivalent inside the hive to the activity of the foraging flight outside it. This is a big assumption, but it seems to be the minimum for any understanding of the problem, for the opportunities which the individual bee can have for perfecting, still less for learning, this astonishing behaviour appear quite insufficient. Thus although correct *perception* and *interpretation* of the dance are undoubtedly rewarded by finding the food source, the time available to the short-lived worker bee for improving such an elaborate performance by practice seems altogether inadequate. Moreover, even though a correct interpretation of the dance is rapidly rewarded, by finding food, correct performance of the dance can scarcely be rewarded at all.

There is one particular difficulty which presents itself on first reading of this work, but which I find after observing for myself no longer looms so large. This is the problem of how the bees themselves can observe the characteristics of the waggle dance when it is performed on the crowded surface of the comb in an absolutely dark hive. It is important to remember that the successful foragers give up some food to the other bees on first returning to the hive. They then do the dance. The bees nearby are excited by the dance and appear to appreciate its direction by following close on the waggle run. They thus experience both the angle and speed of the dance by themselves following the waggle run immediately in the wake of the returning forager.

Von Frisch[4] has now shown that the direction-giving is, under good conditions, accurate to about 3°, whereas the distance indication is on the average accurate to about 100 m. The accuracy with which the angle between the axis of the waggle run and the vertical is measured by the bee is an astonishing feature of the results, and from our present knowledge of insect proprioceptors it is not easy to imagine how it is achieved. Indeed, the mere *visual* perception of angles to such accuracy when on foraging flights is very remarkable, for Baumgartner[4] has shown that the minimum angular separation of adjacent ommatidia in the bee's eye is 0·9°. With regard to distance estimation, it appears, as a result of a large number of experiments on efficiency under varying wind conditions, that this is the result of some sensitiveness to the amount of energy expended on the outward flight. The advantage in estimating the distance on the outward flight is probably that the bee is then unladen and her weight and flight conditions constant. On the return flight, the load carried will vary according to whether she is foraging for pollen or nectar, and probably with other conditions also; moreover, it is the correct estimate of distance under the wind conditions of the outward flight that matters. The visual estimation of direction, while theoretically simple enough for an animal with good light-compass orientation such as the bee, when foraging in open country without serious obstacles, may nevertheless be a very complex problem under natural conditions, particularly in the broken and mountainous country in which von Frisch's experiments were performed. Bees are somewhat reluctant to fly high over obstacles and tend at first to go round rather than over impediments such as high cliffs and mountain sides; although later, if the detour is excessive, they may quickly learn to straighten the path. Von Frisch, as a result of some preliminary detour experiments, concludes that bees indicate the actual distance flown on the detour but give approximately the true direction of the food source in relation to the sun—not the direction on which they set out. A moment's thought will show that, in fact, this is the simplest way in which direction-giving could be made effective in country where obstacles have to be negotiated.

The waggle dance is occasionally performed on the horizontal surface of the alighting board in front of the hive, and under these conditions the waggle run serves as a pointer indicating the *actual* direction of the feeding place, not its direction in relation to the sun; for obviously, on a horizontal surface, the type of dance involving reference to gravity is impossible.

A bee performing the vertical form of the waggle dance on the comb in its normal position can immediately be induced to perform the horizontal form by moving the hinged vertical comb of the observation hive to the horizontal position—provided only that a good deal of daylight is being admitted to the hive (in actual fact as long as some blue sky is visible to the bees). In the dark, bees (as observed by a red light to which they are insensitive) are always disorientated when on a horizontal surface or when daylight is too diffuse or reduced below a certain intensity. The primitive function of this horizontal dance is completely obscure. The horizontal alighting board is, of course, entirely unnatural and it is hard to imagine how under natural conditions there could ever be a horizontal surface available for direction-giving.

It is evident that the bees cannot remember the turns which they have taken on the horizontal plane after they have entered the dark hive, and can no longer give the absolute direction unless they are subject to some stimulus received from the daylight, sight of the sun itself not being necessary. If they are given a strong *beam* of light from an electric lamp inside the hive, the straight run of the waggle dance is found to make the same angle with the lamp as the actual path from the hive to the food source makes with the sun, the lamp being reacted to as if it were the sun. But, of course, this is a highly artificial situation. As a result of a long series of experiments, von Frisch found that sight of a very small area (10°) of the blue sky at any point of the compass is sufficient, quite independent of its direction, to maintain correct orientation of the dance on the horizontal surface. If, however, when the aperture is to the north, light from, say, the western side is reflected down the tube into the hive by a mirror, the bees now dance incorrectly, behaving as if west was north. We are thus forced to the conclusion that daylight in itself without sight of the sun has some orienting capacity independent of its direction. A confirmation of this astonishing conclusion was obtained from an entirely different set of observations and experiments, 3,600 in number, planned and carried out in previous years for another purpose (ref. 4, pp. 144–45). Unfortunately, lack of space forbids discussion here of this very impressive evidence.

It appears that the only explanation of all these similar experiments is that the bees are sensitive to the polarization of the light reflected from the blue sky, and by this means are able to tell the direction of the sun even though they can see only a small area of the sky far removed from the sun. The light from the blue sky is partly polarized, and this polarization shows a two-fold relation to the position of the sun; first, the degree of polarization increases as one passes across the sky away from the sun, to reach a maximum of 60–70 per cent at about 90°, declining again towards a point opposite the sun. In a considerable circle around the sun and also around its opposite point the degree of polarization is very slight. Secondly, the plane of polarization of the light from different parts of the sky bears a regular relation to the sun's position. Von Frisch points out that the human eye is slightly sensitive to polarization of light, as is shown by the visual phenomenon known as 'Haidinger's tufts'; and it appears that some individuals have a higher sensitivity than others in this respect[7]. He assumes that compound eyes are particularly well adapted to analyse polarization of the sky light (although he offers no suggestion as to the means by which this might be done), and that it is perception by the bees of the pattern of polarization thus visible to them in the sky which enables them to determine the actual position of the sun.

Obviously these conclusions pose very considerable problems to those concerned with the physiology of vision in general and the structure of the arthropod eye in particular. Be this as it may, the evidence that polarization of the light from the sky is the effective stimulus is very great. As I myself observed, one can alter the direction of the horizontal waggle dance of the bees by changing the direction of polarization of the light. The effect of placing a 'Polaroid' screen on top of the glass of the observation hive was to change the direction of dancing in the same degree and direction as the turning of the 'Polaroid' screen from the zero point; but when this turn had reached approximately 55°, the bees were completely disorientated and danced at random in all directions. In a series of sixty-two experiments in which the bees were screened from all but a segment of the northern sky 50° broad, 20° high on an average height of 40° above the horizon, it was found that the change of direction of the dance kept pace steadily with the change in orientation of the 'Polaroid' up to 50°. Similarly, if one leaves the 'Polaroid' in one position and changes the screens so that the bees see a different part of the sky, one obtains a corresponding change in direction of the dance (ref. 5, Fig. 10, 1949). A similar change can be induced relative to the movement of the sun if the 'Polaroid' is left in one position (ref. 5, Fig. 11, 1949).

Von Frisch provides strong evidence that whereas under the glass roof of the observation hive light from the blue sky is essential for orientation of the horizontal dance, bees *outside the hive* can still orientate themselves by the polarization of the light even when the whole sky is covered with thin cloud. It seems safe to assume that under these conditions polarization must be greatly reduced, but of the exact extent of this reduction and of the wave-lengths concerned we are given no clue. It is suggested that the additional depolarization caused by the glass cover of the observation hive is sufficient to account for the inability of the bees to orientate their dances on the horizontal comb under cloudy conditions. This is one of a number of points urgently demanding further study and which will, no doubt, be the subject of the present season's work in Prof. von Frisch's Department.

To sum up: while the mechanism of perception of the polarization remains obscure, the essential facts seem to be well established, and it appears that we are justified in the conclusion which von Frisch himself reaches, that the polarization of the light of the sky is an effective indication for bee orientation and possibly for that of other insects also. Thus, outside the hive and on a horizontal surface, the bees can orientate themselves either by landmarks, by the observed position of the sun or by the polarization of light from the sky—or by any of these in combination. Once inside the hive, landmarks are absent; and on a horizontal plane, therefore, they cannot orientate themselves unless they are given one or other of the remaining two stimuli. Presumably, therefore, the horizontal dance can never be done within a normal hive. Once on the vertical comb, however, they get the orientation supplied by gravity, which now 'stands for' the sun, and they

can thus do the vertical form of their dance even in the dark; for they can remember the direction of the food source in relation to the position of the hive and of the sun.

Prof. von Frisch, by his first work on bee behaviour, published in 1922–23, showed the foraging organisation of the hive to be far more complex than had hitherto been conceived. By this latest work (1946–49) he poses tremendous problems for the neurophysiologist and psychologist and shows that the foraging and orientation behaviour of bees is such as to require a reconsideration of some of the most fundamental concepts used in our explanations of the behaviour of insects and other animals. The day of Loeb and the tropism theory now seems far away indeed. In spite of the fact that the honey bee has been closely associated with man for many centuries, it is now clear that we still have a very long way to travel before arriving at anything like a full understanding of its behaviour and social organisation.

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[3] Von Frisch, K., *Bull. Animal Behaviour*, **1**, No. 5, 1 (1947) (translation of ref. 1).
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OBITUARIES

Dr. Norman R. Campbell

NORMAN ROBERT CAMPBELL was born in 1880 and was the third son of William Middleton Campbell, of Colgrain, Dumbartonshire. He was educated at Eton and Trinity College, Cambridge. He was a student of Sir J. J. Thomson, became a fellow of Trinity College in 1904, and worked mainly on the 'spontaneous' (as it was then often described) ionization of gases in closed vessels. It is not easy, on reviewing the papers by the various workers in this field, to attribute with certainty the credit for establishing the part played by penetrating radiation in producing ionization, but it is clear that he had correctly diagnosed the cause of the phenomena; and it was in the course of this work that, with A. Wood, he established the radioactivity of potassium. In this period also, in studying discontinuous phenomena, he arrived at 'Campbell's theorem' on the effect of random disturbances on a 'receiving' system.

Campbell was appointed to the Cavendish research fellowship at Leeds, when Sir William Bragg was Cavendish professor of physics there, and he became an honorary fellow of that University in 1913. While at Leeds, he continued to work on the ionization of gases by charged particles, and on secondary radiation, then known as 'delta' rays. Soon after the outbreak of the First World War, he joined the staff of the National Physical Laboratory, and was associated with the late Sir Clifford Paterson in investigating the mechanism of the spark discharge produced by plugs for internal combustion engines, which work was described in a number of confidential reports to the Advisory Committee for Aeronautics.

In 1919 Campbell joined the staff of the research laboratories of The General Electric Co., Ltd., which Paterson had undertaken to organise. As an original member of this staff he took a prominent part in establishing those features necessary to assure freedom to the research worker in an industrial organisation; and for many years he was consulted by his colleagues on a wide variety of matters, in which his strikingly original approach was at all times an example and a stimulus.

One characteristic of his scientific work (his willingness to modify conclusions) is illustrated by a series of papers on "The Clean-up of Gases in the Electric Discharge" (published in the *Philosophical Magazine* in the early twenties), though they form only a small fraction of his work between 1919 and 1948. He worked on photo-electric photometry and colour matching, the standardization and theory of photo-electric cells, statistical problems, the adjustment of observations, and (returning, in collaboration with Francis and James, to the theory of random phenomena, the foundations of which he had laid thirty years earlier) the production of 'noise' in thermionic valves and circuits.

In addition to the eighty-eight papers recording this work, Campbell published nine books, of which his "Modern Electrical Theory", "Physics, the Elements" and "Measurement and Calculation" are the most typical of his clarity, his scientific philosophy, and his ability to provoke reconsideration of fundamentals. The acknowledgment, in the preface to his "Physics", to "my masters, Henri Poincaré and Bertrand Russell; but I fear that the latter (at any rate) will think his pupil anything but a credit to him", was entirely characteristic of both the friend and the controversialist. So also was the fact that Campbell undertook the labour of re-writing this large book when the complete original manuscript was lost in the post.

Campbell was a man of the highest principles, and once convinced he was right was uncompromising in his attitude in ethical and scientific discussion. This was apt to lead to controversy—tempered always by readiness to reopen discussions if additional information were provided by his adversary. His chief hobbies were walking and climbing, and he had climbed every Scottish peak over 2,000 ft. He was a delightful companion on these occasions; and he was an excellent host, as those who were fortunate enough to be his guests will well remember.

In 1912 he married Edith Sowerbutts, and they were close companions for nearly forty years; having no children of their own, they adopted a boy and a girl. The last fifteen years of Campbell's life were marred by ill-health, which restricted his physical activities, and he retired in 1944 to their holiday cottage near Lulworth. This was completely destroyed by a bomb later that year, and Mrs. Campbell was severely injured. Ill-health and the loss of their home and nearly all their worldly goods found Campbell still philosophical, logical and unperturbed. The loss of his boy on active service and Mrs. Campbell's death in 1948 he met with great courage, though he was much too deeply attached to them to be unaffected by the loss of their companionship.

Mr. W. Mayhowe Heller

MANY senior members of the British Association, especially those interested in the proceedings and reports of Section L (Educational Science), will learn with regret that one of the first secretaries of the Section, Mr. W. M. Heller, died in Dublin on May 13, at eighty-one years of age. The Section was founded in 1901, with Sir John Gorst, who at

the time was vice-president of Committee of Council of Education, as its first president, and Profs. H. E. Armstrong, John Perry and L. C. Miall and Dr. J. H. Gladstone as vice-presidents. In the previous year Mr. Heller had been appointed senior inspector and head organiser of science instruction by the Commissioners of National Education, Dublin. He held this post until 1923, when he became senior inspector to the Secondary and Technical Branch of the Department of Education of the Free State of Ireland —a post from which he retired in 1933.

In his work up to 1921, Mr. Heller was concerned mainly with primary schools, and he conducted classes for teachers in all parts of Ireland and arranged for the equipment of thousands of schools so that simple instruction in experimental science could be carried out in them. The course of practical work was based upon the Report of a British Association Committee in 1889; and teachers attending training courses had to perform all the experiments themselves. The successful introduction of this kind of instruction into the national schools was followed by the adoption of schemes of practical work in physics and chemistry in the Intermediate or Secondary Schools and by the Department of Agriculture and Technical Instruction.

Mr. Heller was a student of Prof. H. E. Armstrong's at the Central Technical College, now an integral part of the Imperial College of Science and Technology as the City and Guilds College, London. In 1889–92 he was science master at St. Dunstan's College, Catford, where he equipped and organised the science and engineering laboratories in close association with Prof. Armstrong and the headmaster, Mr. C. M. Stuart, the courses of work having the heuristic teaching of scientific method as their basis. Between 1892 and 1900, when he went to Ireland, he was in succession the head of the science side of King's College School, London, inspector and organiser of science under the London School Board, and principal of the Municipal Technical Day School at Birmingham—the first of its kind in Great Britain.

It is a fine tribute to the high regard in which Mr. Heller was held in Ireland, both as pioneer in the field of scientific instruction and in other cultural associations, that he made Dublin his home for nearly fifty years. His ability as a teacher, kindness as an inspector and complete integrity, secured for him a wide circle of friends all over Eire. As an example of his adaptability to changing circumstances, he was proud to attend classes in Irish when the country became the Irish Free State of Eire.

These cordial relationships were greatly strengthened through his wife, Madame Cosslett-Heller, who for forty years was held in the highest esteem in musical circles as the most notable teacher of singing in Dublin and the founder of the renowned Irish Ladies' Choir. She was married to Mr. Heller in 1895, when he was an inspector and organiser of science under the London School Board; and before they went to Dublin in 1901 she had taken up the study of music at the Guildhall School and also at Paris and Frankfort. She was a member of the British Association with her husband until her death in 1944 after fifty years of loving comradeship.

When Mr. Heller was president of Section L at the York Meeting in 1932, he had a distressing fall in the reception room of the Association and sustained a hip fracture which partially crippled him for the rest of his life. He had prepared his presidential address on the subject of "The Advancement of Science in Schools: its Magnitude, Direction and Sense"; but on account of his accident he was in hospital on the evening when the address was to have been delivered, and it was read to the Section by his wife, with Dr. Pickard-Cambridge in the chair.

For thirty-one years before this pathetic occasion, Mr. Heller had been an officer of the Section as secretary, recorder and in other capacities, working with enthusiasm to establish and extend active interest in the scientific method of acquiring knowledge through direct observation and experiment and thoughtful inquiry. As a wise and helpful guide, counsellor and friend, his memory is cherished with high regard by all with whom he came in contact, and as a pioneer in the teaching of elementary physics and chemistry his work in Eire remains an abiding monument to a life of loyal service in the field of educational science. R. A. GREGORY

NEWS and VIEWS

National Physical Laboratory: Sir Charles Darwin, K.B.E., F.R.S.

SIR CHARLES DARWIN, director of the National Physical Laboratory, has announced his intention to retire from public service. He had earlier expressed a desire to be relieved of his duties at the end of last March, and his offer to remain, pending the arrival of his successor, was most gratefully accepted. Sir Charles, grandson of the author of "The Origin of Species", has had a distinguished scientific career at Cambridge, at Manchester under Rutherford until 1914, and at Edinburgh as Tait professor of natural philosophy until 1936, when he became master of Christ's College, Cambridge. In 1938 he was appointed director of the National Physical Laboratory, so he has guided its activities during a period which has been probably the most eventful in its history. Under his leadership, the National Physical Laboratory undertook during the War some of the scientific work on bomb disposal, Mulberry and Pluto, etc., and to establish a link with the scientific work in the United States Sir Charles went to America in 1940 as director of the Central Scientific Office at Washington. On his return in 1942 he was appointed scientific adviser to the Army Council, returning to full-time work at the Laboratory in 1943.

Since the War, the Laboratory has continued to expand, and Sir Charles's broad interests, particularly in the mathematical and physical fields, are reflected in the additions of a Mathematics Division and an Electronics Section to its wide range of departments. He took a leading part, within the Department of Scientific and Industrial Research, in initiating the inquiry which led to the setting up of the new Mechanical Engineering Research and Hydraulics Research Organisations of that Department. Sir Charles is a well-known and popular figure in scientific circles and at conferences concerned with modern

scientific and technical advances. Even to-day, in the midst of his heavy administrative duties, he occasionally presents a paper to a learned society on some topic in the field of theoretical physics. Such papers show the characteristically original point of view and power of development noteworthy of his earlier academic work. His capacity for helpful comment on problems covering most of the range of physical science is quite remarkable and of great value to those working with him. His very wide interests are evidenced by his membership of some sixty committees covering an extremely diverse range of subjects and including the Aeronautical Research Council, the British Association, the Colonial Development Corporation, the University Grants Committee, and the Standing Advisory Committee on Artificial Limbs. He will retain in retirement from official duties many of his present interests, and will live in Cambridge, where he has many friends and close associations.

Prof. E. C. Bullard, F.R.S.

Prof. E. C. Bullard, who is to succeed Sir Charles Darwin, probably in January 1950, is forty-one years old, and was educated at Repton and Clare College, Cambridge. He was appointed demonstrator in geodesy at Cambridge in 1931, and became Smithson Research Fellow in 1936, continuing his work at Cambridge. After the War he returned to Cambridge, and was made reader in geophysics. In 1948 he went to the University of Toronto as professor of physics. In his student career Prof. Bullard followed the ordinary courses in physics, but at the end of it he decided to take up experimental geophysics, and he very soon became one of the leading geophysicists in Britain. He has made important contributions to most of the main subjects in this field, either himself, or through the workers in the Cambridge school of which he was leader, or in some cases by organising co-operative research all over the world. These subjects have included gravity surveys; the seismic method of study of strata buried either under the earth or the sea; the rate at which the earth is losing heat; and terrestrial magnetism. At first, among other things he explored the anomalies in the Great Rift Valley of Africa. The seismic method of artificial explosions was first applied to find the depth of the palæozoic strata in Cambridgeshire, and later, by the use of a submarine, similar work was started to study the strata in the sea around the British Isles. This work had not progressed far when it was interrupted by the War, but it has since been resumed by members of the Cambridge staff. In the matter of the loss of heat from the earth, Bullard has organised the study in both northern and southern hemispheres of the rate of loss of heat from the earth, which gives important information about the earth's radioactivity. During the War he was engaged principally on work for the Admiralty, at first on problems of de-gaussing. Later he was working with Prof. P. M. S. Blackett on a variety of problems connected with the anti-submarine campaign.

Thurlow Navigation Award for 1948: Mr. D. H. Sadler

The Thurlow Navigation Award of the United States Institute of Navigation was founded in 1946 by Mr. Sherman Fairchild (president of the Fairchild Camera and Instrument Corporation, Inc.) in memory of the famous air navigator Colonel Thomas L. Thurlow, who was killed in an air accident in 1944. The award is made each year to the person who, in the opinion of a representative selection committee, contributes most to the science of navigation. The first award, in 1946, for the year 1945 was made to Wing-Commander K. C. Maclure, who was navigator of *Aries* on its flights to the north magnetic and geographical poles. That for 1946 was made to John A. Pierce, the originator of the Loran system of radio hyperbolic navigation, and that for 1947 to Dr. John C. Bellamy, inventor of the Bellamy drift indicator. The award for 1948 has been made to Mr. Donald H. Sadler, superintendent of H.M. Nautical Almanac Office, in recognition of the work of the Office in the field of air navigation, particularly the production for the Royal Air Force of the "Air Almanac" and the "Astronomical Navigation Tables". More recently, the Office, which is part of the Royal Observatory, has been completely redesigning the "Abridged Nautical Almanac", so as to tabulate Greenwich hour angle instead of Right Ascension, and the new form will simplify the sea navigator's task. Because the new methods involve change of syllabus at the navigation schools and other changes, the introduction of the "Almanac" will be deferred until the year 1952. Mr. Sadler joined the Nautical Almanac Office in 1930, after doing research at the University of Cambridge, and was promoted to the post of superintendent in 1936. He was secretary of the Royal Astronomical Society during 1939–47 and vice-president in 1947–48. He played a large part in the formation of the [British] Institute of Navigation.

Botany at Manchester: Mr. George Sutton

At the end of the present session Mr. George Sutton retires from the post of chief steward of the Department of Botany in the University of Manchester, after fifty-two years service. He began work in 1897 as a boy of thirteen under Prof. F. E. Weiss, at a time when the Department occupied a single room, and the professor's assistant was F. W. (later Sir Frederick) Keeble. At his retirement Mr. Sutton leaves one of the largest departments in the country, which owes much to his loyal and skilled help. During his long service Mr. Sutton has won the friendship and gratitude of a succession of botanists, and no less than a dozen chairs are at present occupied by ex-students or ex-members of staff of the Department. At an informal dinner held in Manchester on June 24, and attended by Prof. and Mrs. Weiss, a presentation was made to Mr. Sutton from more than a hundred past and present members of the Department of Botany.

The Technical University, Berlin (1799–1949)

In 1879, the Technische Hochschule was established in Berlin following the fusion of two existing technical academies: the Gewerbeakademie, a species of polytechnic dating from 1821; and the Bauakademie, effectively a technical school for constructional engineers, which was founded in 1799. On this fact rests the claim of the "Technical University" to celebrate its hundred and fiftieth anniversary, and a recently published pamphlet (Von der Bauakademie zur Technischen Universität: 150 Jahre Technisches Unterrichtswesen in Berlin. By Prof. Josef Becker. Pp. 44+6 plates. Berlin-Charlottenburg; 1949) is a description in some forty pages of the history of the Technische Hochschule and its forerunners. The

interest of the pamphlet lies, however, not so much in the typical enough story of past development as in the present situation and its potentialities for the future. The Berlin Technical Highschool was renamed the Technical University in 1946, almost, as it were, in repudiation of its former reputation, and completely in line with the Faustian conception, current to-day among German technicians, that technology cultivated without regard to its social and humanistic responsibilities has a 'dæmonic power' over its practitioners. This conception, which was debated with very marked emotional content at the Darmstadt Conference of Engineers in 1947, has led to a movement among the technical highschools to include some sort of 'humanistic faculty' in their teaching. Aachen and Berlin, at least, have actually taken practical steps in this direction, and it is on these grounds that the Technische Hochschule Berlin-Charlottenburg now claims the title of University. The German technicians appear, in fact, to be finding for themselves a rationalization of the apocalyptic destruction, material and moral, of the German debacle; and it may well prove that the outward expression will not be confined in the future to mere platform oratory and piously expressed intentions. On the contrary: the German capacity to rationalize a strong emotional surge in fact and deed may have important consequences in the future bias of technical education in Germany. It is here, if anywhere, that the Berlin pamphlet is significant.

International Health Bulletin

THE first (January–March 1949) issue of a new quarterly journal, entitled *International Health Bulletin of the League of Red Cross Societies*, published in French and English (8 rue Munier-Romilly, Geneva; 6 Swiss francs, or 1.50 dollars a year), shows that Red Cross Societies and their medical advisers now have a unified and well-edited epitome of the medical aspects of international Red Cross work. Designed to replace the League's *International Health Review* and to revive its earlier surveys of medical and scientific literature, this new bulletin will summarize the most recent and original projects undertaken by the various national Red Cross Societies and will report important medical developments likely to interest Red Cross workers. Described by its editor as a "modest review, designed to appeal to all Red Cross medical advisers", the bulletin is not intended to rival other scientific publications; but it will be surprising if it does not interest many who do not actually work for the Red Cross. In the first issue there are articles by medical men of many nationalities, including articles on co-operation between the League of Red Cross Societies and the World Health Organisation, on the League's extensive and thorough campaign against tuberculosis, on its relief work in the Near East and on its work on venereal diseases, blood-transfusion, first aid, social service and other problems. About half this issue is given to medical information under the heading of "Medical News", examples of the items discussed being the risks of new drugs and the uses of aureomycin and streptomycin. A short survey of books and a list of the films in the League's film library add to the value of this number. The information given about the contents of future issues suggests that these will be no less interesting. No doubt there will be a big demand for the two forthcoming special issues, one entitled "Atomic Bomb and Atomic Medicine" and the other "Cancer Detection".

Standardization of Units of Measurement in Civil Aviation

THE Montreal headquarters of the International Civil Aviation Organisation has announced that substantial progress has been made towards the solution of a problem, in the world of air transport, that has always made difficult the international exchange of ideas, namely, the standardization of units of measurement used in scientific work. Although this problem is not peculiar to aviation, the result of a misunderstanding due to a multiplicity of measuring units is likely to be more disastrous to the occupants of aircraft in flight than to anyone else. The plan consists of an agreement to use five tables of units, incorporating both the metric and the foot-pound-second systems. The first table uses the English system (except that it measures temperatures in Centigrade instead of Fahrenheit). Each other table introduces alterations leading progressively towards the metric system, the change in each case being the one that the organisation has agreed will be the next most easy to adopt. The final (fifth) table uses the metric system, with the exception of nautical miles and decimal parts for long distances and speeds. Time is measured in twenty-four hours, beginning at midnight Greenwich Mean Time. At present there are at least fourteen different combinations of units in use within the territories of the member States of the Organisation. Table 5, the complete adoption, has been accepted immediately by sixteen nations, and eighteen others, of which Great Britain is one, have accepted one of the other four tables and will progress towards the final standardizations in due course. There are fifty-two member nations in the world organisation.

Cambridge School of Veterinary Medicine

THE University of Cambridge has decided to initiate a course of veterinary teaching, and powers are being sought under the Veterinary Surgeons Act, 1948, to confer a degree in veterinary medicine that will be a registerable qualification. In October a limited number of veterinary students will begin a six-year course leading to this degree, of which the first three years will be spent in study for the Natural Sciences Tripos, and the following three years in professional studies. It is probable that colleges will stipulate the passing of three of the four parts of the First M.B. Examination as the necessary condition for admission to the course. Plans are being drawn up for the erection of buildings for the new School of Veterinary Medicine, which will be situated within two miles of the centre of Cambridge on an area of approximately 120 acres of farmland. Financial provision for these courses will be made by the University Grants Committee, and £31,000 has been allocated for 1949–50.

Exhibition of Joule's Water-Friction Apparatus

IN June 1849, J. P. Joule announced the results of extensive researches carried out in Manchester, in which he found that the expenditure of energy, in whatever form, is always accompanied by the production of a corresponding amount of heat. Prior to this, there had been considerable disagreement among men of science concerning the nature of heat; some held it to be a material fluid (called caloric) which permeated the space between particles composing a hot body, while others attributed it to the mechanical energy of these same particles which were to be

regarded as being in rapid motion or vibration. Joule's work settled the controversy in favour of the second alternative, and thereby laid the foundation for the modern theory of heat. With a water-friction apparatus Joule obtained the experimental result that to heat a pound of water through one degree F. requires 772 ft. lb. of mechanical energy. This original apparatus is preserved at the Science Museum, South Kensington, London, S.W.7, and is on special exhibition there until the end of July.

1851 Exhibition Senior Studentship Awards

THE Royal Commission for the Exhibition of 1851 has announced the award of senior studentships for 1949 to the following for research work to be carried out at the places stated: Dr. J. W. Craggs (applied mathematics, at the University of Cambridge); Dr. A. J. B. Robertson (physical chemistry, at the Royal Institution of London); Dr. N. Sheppard (physical chemistry, at the University of Cambridge); Miss Janet Watson (geology, at the Imperial College of Science and Technology, London). The awards are of the value of £600–650 a year and are ordinarily tenable for two years.

Colonial Service: Recent Appointments

THE following appointments in the Colonial Service have been announced: J. J. Lowes, agricultural officer (soil conservation), Nyasaland; E. F. Bradford, geologist, Federation of Malaya; Miss M. N. Massie, veterinary officer, Tanganyika; D. A. Davies, director of East African Meteorological Service, East Africa High Commission; R. N. Champion Jones, agricultural development officer, Nigeria; J. B. Philips, development officer, Veterinary Department, Nigeria; G. D. Scott, pasture research officer, Tanganyika; C. H. B. Williams (deputy director of agriculture, British Guiana), deputy director of agriculture, Trinidad; J. Wright (senior agricultural officer, Jamaica), deputy director of agriculture, Jamaica; A. Foggie (senior assistant conservator of forests, Gold Coast), conservator of forests, Gold Coast; H. Fraser (senior assistant conservator of forests, Tanganyika), working plans officer, Tanganyika; Dr. J. W. Field (senior medical research officer, Institute of Medical Research, Federation of Malaya), director of the Institute of Medical Research, Federation of Malaya; R. B. Heisch (parasitologist, Kenya), senior pathologist, Kenya; R. W. Crowther (veterinary officer, Cyprus), veterinary research officer, Cyprus; H. T. B. Hall (Government veterinary officer, Fiji), deputy director of agriculture (veterinary services), Jamaica; L. R. Hutson (veterinary officer, Barbados), chief veterinary officer, Leeward Islands; C. W. Wells (veterinary officer, Federation of Malaya), chief veterinary officer, Singapore; D. G. White (senior veterinary officer, Tanganyika), assistant director of veterinary services, Tanganyika; G. F. Cole (senior marine officer, Tanganyika), chief fisheries officer, Lake Victoria Fisheries Service; H. T. Lloyd (assistant agricultural officer, Kenya), agricultural officer, Kenya; E. G. Young (agricultural development officer, Nigeria), agricultural superintendent, Nigeria.

University of London: Appointments

PROF. LILLIAN M. PENSON has been re-elected vice-chancellor of the University of London for the year 1949–50, and Prof. H. Gordon Jackson, master of Birkbeck College, has been appointed deputy vice-chancellor. Dr. M. G. Kendall has been appointed to the University chair of statistics tenable at the London School of Economics and Political Science as from October 1; Dr. Christoph von Fürer-Haimendorf to the University readership in anthropology with reference to India tenable at the School of Oriental and African Studies as from October 1.

The title of emeritus professor in the University has been conferred on the following: Prof. W. T. Gordon, professor of geology at King's College since 1920; Prof. F. L. Hopwood, professor of physics at St. Bartholomew's Hospital Medical College since 1924; and Prof. Doris L. Mackinnon, professor of zoology at King's College since 1927.

The degree of D.Sc. has been conferred on C. J. Eliezer (an external student).

International Meeting for Optics

AN international meeting for optical science is being organised to be held in London during July 17–26, 1950, in connexion with the official sessions of the International Optical Commission. The programme will include papers and lectures on optical subjects, an exhibition of optical apparatus and instruments, and visits to various laboratories and industrial firms. The organising committee (appointed by the optical sub-committee of the National Committee for Physics with the approval of the Council of the Royal Society) is acting under the chairmanship of Prof. R. W. Ditchburn, with Prof. L. C. Martin, of the Imperial College of Science and Technology, as honorary secretary, and Mr. A. J. Philpot, director of the British Scientific Instrument Research Association, as treasurer. Further particulars will be announced in due course.

Announcements

PROF. H. U. SVERDRUP and Prof. Hans Pettersson have been elected honorary members of the Marine Biological Association of the United Kingdom.

SIR ALFRED EGERTON, head of the Department of Chemical Engineering and Applied Chemistry at the Imperial College of Science and Technology, London, has been appointed director of the Salters' Institute of Industrial Chemistry, in succession to the late Sir Robert Robertson.

THE British Rheologists' Club is holding, jointly with the Midland Chemists, a conference on "The Rheology of Thickened Liquids" in the University of Birmingham during July 15–16. The chairman for the first day will be Prof. F. H. Garner, and for the second day, Dr. A. H. Nissan. Applications for attendance should be addressed to Mr. R. B. Shearn, Chemical Engineering Department, University, Edgbaston, Birmingham 15.

AT a special meeting of the Council of the Association of University Teachers of Scotland, held in Edinburgh on June 18, final arrangements were made for the affiliation of this Association with the Association of University Teachers of England, Wales and Northern Ireland. The Scottish group retains its own constitution within the wider framework.

A NOTICE appeared in *Nature* of June 11, p. 895, of "The Failure of Metals by Fatigue", published by the Melbourne University Press; we are informed that this book is available in Great Britain from the Cambridge University Press, which acts as agent for all publications of the Melbourne University Press.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Reduction of Optical Reflectivity of Glass Surfaces Resulting from Ion Bombardment

THE bombardment of glass by ions under certain experimental conditions may result in a permanent change of the surface such that the reflexion of light from the surface is reduced and also the transmission through the glass is increased.

This effect of ion bombardment was accidentally found about nine months ago while using the mass-spectrograph of this Institute[1] for isolating radioactive krypton isotopes. During these experiments a gas mixture mainly consisting of normal krypton was taken as starting material. In order to collect the gaseous isotopes, beams of energetic krypton ions were directed toward a metal plate. It is known that such a plate is capable of retaining incident atoms in the surface[2]. A small part of each isotopic beam, however, was allowed to impinge on a plate of crown glass, used as a fluorescent screen, in order to observe and fix the mass-spectrum during the time of collection. The inspection of this glass plate later showed a slight decrease of the reflectance of light at the places hit by the strongest ion beams.

In the experiments which followed and which were designed for a closer study of this phenomenon, the beam containing ions of the abundant krypton isotope (Kr^{84}) was uniformly spread over an area of about 3 cm.², which was limited by a metal frame. The spreading was accomplished by applying an A.C. voltage to a deflecting condenser, which in ordinary separation experiments was used for stabilizing the beams[3]. The energy of the ions was 60 keV. and the current density, which could not be measured directly, was estimated from earlier measurements to be about 20 μamp./cm.². The glass plates could be observed from the outside, and already after twenty minutes of irradiation it was possible to detect a change in reflectance, which proceeded quickly in the course of the next few hours. Later a constant value was approached slowly. This process could also be followed to a certain extent by observing the fluorescent light from the glass. At the beginning of the irradiation it was very feeble and had a bluish colour. After a short time it became an intense yellow; and after some hours a decrease in brightness set in, and the colour became light blue.

λ mμ		400	500	550	600	700
T_{Kr}	%	91·5	96·0	96·8	95·0	89·0
T_u	%	88·6	91·0	91·0	90·0	84·8
ΔT	%	2·9	5·0	5·8	5·0	4·2

Values of the spectral transmission factor measured on a plane plate of crown glass (thickness, 0·3 cm.; $n_D = 1{\cdot}5177$; $\frac{n_D - 1}{n_F - n_C} = 56$); T_u, transmission factor of untreated glass; T_{Kr}, transmission factor after krypton bombardment; ΔT, change in transmission factor.

The effect of irradiation for ten hours on each side of a plate of crown glass can be seen from the accompanying table, which gives some values from curves of the spectral transmission factor, as measured by means of a Beckman spectrophotometer before and after treatment with krypton. The transmission factor has been considerably increased at all wave-lengths as a consequence of the treatment, especially around the maximum of the T_{Kr}-curve, which occurs about 550 mμ, where only 3·2 per cent of the light is lost in passing through the plate. The curve corresponding to the spectral reflexion factor could not be measured directly by means of the spectrophotometer available, but its approximate course can be found from the measurements above and by using Fresnel's formula for calculating the reflexion factor of the untreated surface. The krypton-treated glass has a bluish-brown colour when observed in reflected white light.

The krypton-bombarded glass surfaces appear to have a rather high resistance to external influences. Heavy and repeated rubbing with a cloth did not apparently change the surface, which, however, could not withstand scraping with a knife. The surface resisted treatment with nitric or chromic–sulphuric acid. Furthermore, it was found that a temperature of about 400° C. did not change the reflexion properties. This result is in accordance with the fact that the glass gets very hot during the ion bombardment.

In order to obtain more detailed information on the character of the phenomena observed, a series of experiments was carried out with different kinds of glasses and bombarding ions. The first result was that all types of crown glass used showed a reduction in the reflexion factor by krypton bombardment, and it was especially noted that flint glass also could be strongly influenced. The bombardment of crown glass by argon and xenon ions also showed a reduction of reflexion, but less marked. The colour of the reflected light was blue and brown for argon and xenon, respectively.

No appreciable decrease of reflexion was obtained by irradiating crown glass with the other inert gases, neon and helium, or with hydrogen or nitrogen. After a run of twenty hours with neon, the glass surface showed a white tinge, which even decreased the transmission of light. Thirteen hours of irradiation with helium also led to a slight decrease in transmission, which disappeared in time and which could be entirely destroyed by treatment with chromic–sulphuric acid. An experiment with H^+ ions (ten hours bombardment) did not change the optical properties of the glass; but after a similar experiment with H_2^+-ions the glass surface became a red colour. Bombardment with N^+- and N_2^+-ions resulted in red-yellow and blue colours, respectively. The different results produced by the use of atomic and molecular ions may be due to the fact that the molecular ions are split into atoms when they hit the surface, each having half the energy of the atomic ions used in the experiments.

The experimental material so far obtained is probably not sufficient for a complete explanation of the phenomena in question. Continued investigations along the lines described above, including the variation of energy and current density of the ions, would give some further information, but it may be necessary to use other methods of approach. The reflexion-reducing effect, however, is certainly due to the formation of a surface layer, of a thickness of the order of a quarter of a wave-length, having an index of refraction which is very small immediately at the surface but which at greater depths may approach continuously that for the untreated glass. The formation of this layer, however, must be caused

indirectly by the impinging ions, for they have a range which, according to theory[4], is only about one hundred atomic diameters, that is, about a tenth of the thickness of the layer in question. These calculations are in agreement with disintegration experiments carried out with the isotopes of neon[5] and argon[6] collected in the surface of silver, which gave the additional information that maximum concentration is approached when the silver surface has been hit by about 6×10^{16} atoms per cm.^{2}. The fact that more than ten times as many ions are necessary to produce the highest obtainable reduction of reflexion seems to support the idea that special conditions such as electrical forces due to space charges and the high temperature of the surface may play an important part.

The procedure described may possibly be applicable to the preparation of reflexion-reducing surfaces on optical elements[7], since the ion-bombarded surfaces seem to have some advantages over those prepared by coating methods. Although these questions, and many others, have not been completely investigated, we have decided to publish the present material, since the mass-spectrograph in the future will be mainly occupied by separation experiments.

I wish to thank Prof. Niels Bohr for his continued interest in the present investigation. I should also like to thank Mr. S. Møller-Holst and Mr. S. A. Djernes for their help during the long irradiations.

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Observation of Nuclear Disintegrations Below Ground

We have kept some Ilford Nuclear Research photographic plates in our underground laboratory, which is at a depth of 30 m. under London clay (60 m. water-equivalent). Hot liquid emulsion was brought from the Ilford works to the laboratory, where the required volume was measured out in a measuring cylinder and then poured on to a horizontal glass plate. After leaving to dry for one day, the plates were cut to a convenient size and stored vertically. After a period of sixty days, they were developed in the same underground laboratory. We feel confident that any nuclear tracks we observe were produced underground. We have so far examined 10 c.c. of emulsion, and have found six nuclear disintegrations containing three or more tracks. This gives a rough estimate for the rate of production of these stars at this depth of $\sim 0{\cdot}01 \pm 0{\cdot}004$ stars/c.c./day. The numbers of tracks in the various stars were as follows:

No. of tracks in star, n	3	4	5	6
No. of stars with n tracks	1	1	3	1

Since we observe $1{\cdot}5 \pm 0{\cdot}07$ stars per c.c. per day at sea-level, the ratio of the sea-level to the underground frequency of stars may be placed at about 150 ± 60.

The radiation responsible for the majority of the stars above ground is strongly absorbed in air and other light materials with a range[1] ~ 160 gm./cm.^{2}, and would give rise to about 10^{-17} stars/c.c./day at a depth of 60 m. water-equivalent. It may be assumed, therefore, that the stars observed underground are produced by a radiation differing from that which produces the bulk of the stars observed above ground. We may tentatively assume that the underground stars are secondary in some way to the penetrating component of cosmic radiation, the μ-mesons.

One possible mechanism for the production of the stars is that a μ-meson is scattered by a nucleon, the recoil momentum of the latter being sufficiently large to cause the disintegration of the parent nucleus. The cross-section per nucleon for this process would then have to be

$$\sigma_\mu = 0{\cdot}5 \times 10^{-28} \text{ cm.}^2 \qquad (1)$$

to account for the observed frequency of stars. The mean energy of the μ-mesons at this underground depth is 10^{10} eV. The cross-section for the production of a recoil proton with an energy of 100 MeV. (sufficient to cause a small star) by means of Coulomb forces alone is calculated to be $\sigma = 10^{-30}$ cm.^{2}—much smaller than the cross-section (1) above. A possible interpretation is therefore that the cross-section (1) results from a short-range interaction between μ-mesons and nucleons.

Observations on the large-angle scattering of fast particles in cloud chambers at sea-level have led to a figure of $\sim 5 \times 10^{-28}$ cm.^{2} for the cross-section for the anomalous scatter of mesons[2]. The difference between this and (1) may be due possibly to the higher mean energy of the mesons underground, or to the production of stars being a more stringent requirement than the large-angle scattering observed in the cloud chambers.

Alternative explanations which must be considered are that the stars are caused by (i) the electrons or photons that are produced underground by the μ-mesons; (ii) neutral particles that may be produced locally by the μ-mesons, or in the atmosphere by energetic primary particles, and then have penetrated underground.

If the stars are produced by the soft component, then this would require an average cross-section of

$$\sigma_e = 7 \times 10^{-26} \text{ cm.}^2 \qquad (2)$$

for the photo- or electro-disintegration of nuclei, and this does not appear to be very likely.

We are repeating the experiment with plates that will record the tracks of particles with minimum ionizing ability, and hope to be able to decide whether the stars are caused by charged or neutral particles.

Our thanks are due to Messrs. Waller and Vincent, of Ilford, Ltd., for coating the plates underground.

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E.C.4.

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Structure of Cosmic-Ray Air Showers

THE lateral distribution function of extensive cosmic-ray showers has been investigated with ionization chambers in coincidence by Lewis[1] at 3,100 metres, and more recently by Williams[2] at 3,050 metres. We wish to report the results of a similar investigation with two ionization chambers at sea-level.

The chambers were steel cylinders of wall-thickness 0·175 cm., and the effective volume was enclosed within an outer electrode of diameter 8·8 cm. and an inner, collecting, electrode of diameter 3·3 cm., both electrodes being of wire gauze and of length 58 cm. They contained nitrogen at a pressure of 39 atmospheres. The smallest burst used corresponded to a shower density of 600 rays per square metre, and an energy loss of 16 MeV. Positive ion collection was used. The observations covered about 1,600 hours and were carried out between December 1947 and September 1948, shortly after which the apparatus was destroyed by fire.

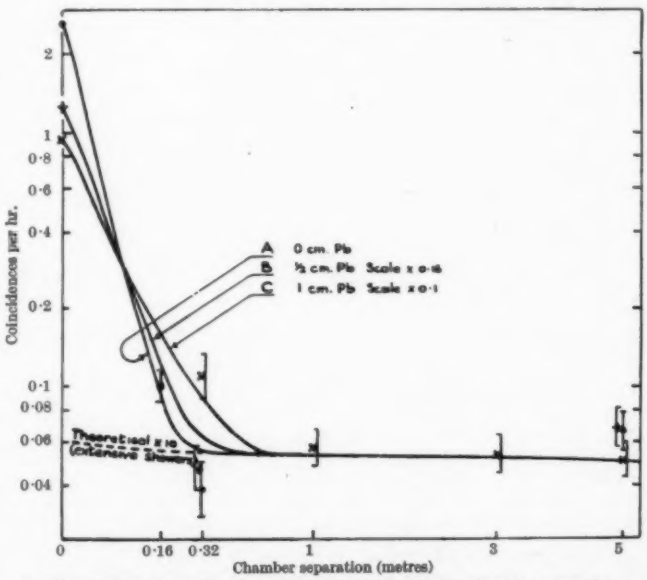
The coincidence-rate as a function of chamber separation is shown in the accompanying graph, the most probable curve being drawn through the experimental points. Curves *A*, *B* and *C* correspond to runs in which the chambers were covered with 0, 0·5 and 1 cm. of lead respectively, the three curves being adjusted to fall together at large separations for comparison purposes, by the use of suitable multiplying factors. The rate for zero separation is the rate for either chamber alone. The variation of coincidence-rate with separation predicted by theory[3,4] for extensive showers is relatively small, as we find for separations greater than 0·3 metres. The very large increase at zero separation must be attributed largely to nuclear disintegrations that occur in one chamber only[5,6]. The evidence supplied by the addition of lead shielding to the chambers indicates, however, that disintegrations cannot be wholly responsible.

The air–lead transition curves for a single chamber include bursts due to both disintegrations and showers. Of these the former are not markedly affected in frequency by the addition of lead[7]. Extrapolating the flat portion of curve *A* in the graph in accordance with the theoretical calculations of Wolfenstein[4] gives a rate of 0·06 per hour for extensive showers. If we assume that the remainder of the 2·6 bursts per hour in a single chamber without lead is due entirely to disintegrations, we obtain a rate of 2·54 per hour for disintegrations, which we can take as constant for all thicknesses of lead. Subtracting this value from the single-chamber rate of 7·0 per hour for 0·5 cm. of lead, we obtain a shower-rate of 4·46 per hour. This represents a 70-fold increase over the rate with no lead, an increase which is far too great.

Values for the increase in rate produced by lead may be obtained from the work of Montgomery and Montgomery[8] with a single chamber, in which allowance was made for bursts due to nuclear disintegrations. Agreement is obtained with their values for a shower density the same as ours, if we take a rate for disintegrations of 1·45 per hour. The remaining 1·15 bursts per hour is then made up of an extensive-shower rate of 0·06 per hour, and a rate of 1·09 per hour which must be attributed either to the core of a shower the particle density of which in its fringes is too small to be detected, or to a shower of small extent still in the process of development. It is possible to think of burst-producing mechanisms other than narrow showers of this type, which will give an increased burst-rate when lead is placed above the chamber (for example, the production of nuclear disintegrations by photons in the photonuclear effect); but it is difficult to estimate the contribution of such an effect. It seems simpler to attribute our effect to narrow showers, the existence of which has been established for showers of lower density by Alichanian and Asatiani[9] with coincidence counters. It is probable that most of our coincidences at small chamber-separations are also due to narrow showers. Williams, however, finds no evidence for narrow showers at 3,050 metres.

It should be noted that while about half the bursts observed in our chambers are due to disintegrations and the remainder to showers, Bridge, Hazen, Rossi and Williams[6], using the same chambers as Williams at 3,500 metres, attribute 98 per cent of their single-chamber bursts to disintegrations. Their higher proportion of disintegrations could be attributed to the use of a gas pressure one-eighth of that in our chambers and to the use of argon instead of nitrogen.

It appears that the only reliable method of measuring extensive shower-rates for showers of a given density is to use coincidence chambers sufficiently far apart to avoid recording narrow showers or disintegrations. Our rate for extensive showers of density greater than 600 particles per square metre is 0·06 per hour, which is ten times the rate predicted by



Coincidence-rate for bursts of greater than 30 particles, corresponding to a mean shower density of greater than 600 particles per square metre. The curves for lead above the chambers are adjusted to coincide with the curve for no lead at the larger separations by the use of appropriate multiplying factors

Wolfenstein. The rates obtained by Lewis and by Williams at the higher altitude for a chamber separation of 10 metres and for showers of the same density are also much greater than the predicted rate, by factors of 280 and 12 respectively. Part of the discrepancy may well be attributed to Wolfenstein's inclusion of the zenith angle effect, whereas recent experiments[2] indicate that extensive showers penetrating to the lower altitudes are incident nearly vertically.

Further details of the present work are to appear in the *Australian Journal of Scientific Research*, Series A, **2** (1949).

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March 17.

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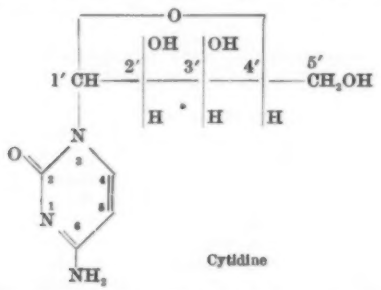
Crystal Structure of Cytidine

A STUDY of the crystal structure of cytidine is being carried out by X-ray analysis. The crystal specimens were kindly supplied by Dr. D. O. Jordan, University of Nottingham, and were found to be orthorhombic with {110} dominating. An optical investigation shows that the sign is positive, with $\alpha \| c$, $\beta \| b$ and $\gamma \| a$. Cell dimensions are: $a = 13{\cdot}93$ A., $b = 14{\cdot}75$ A., $c = 5{\cdot}10$ A.; density, 1·53; four molecules per unit cell; space-group, $P\,2_12_12_1$.



Cytidine

Weissenberg photographs were taken, approximate atomic co-ordinates postulated by trial and error, and the Fourier map of the 001-projection shown in Fig. 1 eventually obtained. This map is now being refined.

Fig. 2 gives the interpretation of the peaks. The chemical formula is fully confirmed, thus showing cytidine to be cytosine-3-*d*-ribofuranoside. The glycosidic linkage is of the β-type, in accordance with the findings of Davoll, Lythgoe and Todd[1]. The bond-angles to the atom C_1' of the five-membered ring are not far from the tetrahedral angle, and the planes of the two ring systems are nearly perpendicular to each other. Details of the structure cannot be given at this stage; but the pyrimidine-ring appears

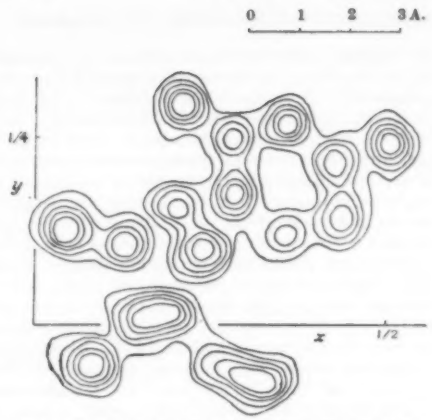


Fig. 1. Fourier projection of cytidine in direction of c-axis

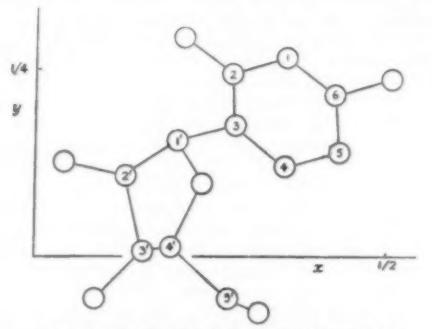


Fig. 2. Molecular projection corresponding to Fig. 1

to be flat, and there is some indication that the ribose-ring may not be planar.

Neighbouring molecules in the crystal are held together by hydrogen bonds.

It is hoped to publish later a more detailed account of the structure.

X-ray work on cytidylic acid is also in progress. The cell-dimensions are $a = 8{\cdot}74$ A., $b = 21{\cdot}4$ A., $c = 6{\cdot}82$ A., and the space-group $P\,2_12_12$.

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Runge Bands of O_3 in Flame Spectra

IN a recent note, Hornbeck[1] has reported observing the Runge emission bands of O_3, $^3\Sigma_u^- \rightarrow {}^3\Sigma_g^-$, in the spectra of explosion flames of carbon monoxide and oxygen, and has shown that this banded structure is favoured relative to the continuous background by excess of oxygen in the mixture. In a diffusion flame of carbon monoxide burning in oxygen at atmospheric pressure, we have confirmed the presence of the Runge bands, the (0,13), (0,14) and (0,15) bands, with heads at 3233, 3370 and 3516 A., being conspicuous. These bands, however, are emitted by a different part of the flame from the main carbon monoxide flame spectrum, and it is clear that the

characteristic diffuse banded structure of the carbon monoxide flame spectrum, which has formed the subject of an investigation by one of us[2], is not connected with the Runge band system. Direct comparison of spectrum negatives of the older carbon monoxide – air flame spectra and the new spectra of the carbon monoxide – oxygen diffusion flame show that the Runge bands are definitely absent from the older plates.

We have also observed the Runge bands fairly strongly in a diffusion flame of hydrogen burning in oxygen, the bands again being emitted by a different part of the flame from that giving the strong OH bands.

It is not clear whether the emission of the Runge bands by flames is due to thermal excitation of the oxygen or to chemiluminescence. About 6·1 eV. is required to excite the system, a relatively high energy for thermal excitation in a flame; but it may be noted that the bands occur in the hot flames with oxygen, and especially well in the explosion flames in closed vessels, where there may be heating by strong compression waves, but have not been observed in the cooler flame with air. The occurrence of the bands in both carbon monoxide and hydrogen flames makes it seem likely that if the excitation is due to chemical processes then these do not involve a reaction of carbon monoxide, but only of some oxygen product such as ozone.

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Saint-Venant's and Filon's Finite Strains: Definitions Non-Linear in Displacement Gradients

Saint-Venant, in 1847, first introduced 'finite strains' expressions non-linear in displacement gradients[1] with the co-ordinates of the current point in the undeformed body. Filon, in 1931, introduced the analogous non-linear expressions but with the co-ordinates of the point referring to its actual position after deformation[2]. Pearson, in 1886[1], pointed out that Saint-Venant really treated only small strains, while Filon stated that his own 'finite strain' expressions could be interpreted as physical strains only when strains were small[2].

I wish to point out that these non-linear expressions, accepted by all recent writers except myself, merely occur in defining the strain quadric and should not be interpreted as physical strains related to the stresses operating. The simple case of pure normal straining parallel to the Cartesian co-ordinate axes will illustrate the argument and show that linear displacement gradients are sufficient to analyse finite strains.

A point in the deformable body is initially at vector position $\mathbf{R}^\circ$ and displaces by $\mathbf{D}$ to position $\mathbf{R}$. Then,

$$\mathbf{R} - \mathbf{D} = \mathbf{R}^\circ. \tag{1}$$

The strain is homogeneous, so $\mathbf{D}$ can be expressed in terms of $\mathbf{R}$ and the vector gradient operator $\vec{\nabla}$. Introduce the idemfactor $\bar{\mathbf{I}}$, the conjugate $\vec{\nabla}_c$ of $\vec{\nabla}$ and square (1) by forming the scalar product to give[2]

$$\mathbf{R} \cdot \vec{\varphi} \cdot \mathbf{R} = R^{\circ 2}, \tag{2}$$

where

$$\vec{\varphi} = (\bar{\mathbf{I}} - \vec{\nabla}\mathbf{D}) \cdot (\bar{\mathbf{I}} - \mathbf{D}\vec{\nabla}_c). \tag{3}$$

The argument has been simplified here for brevity by considering pure normal straining. Thus with R_i, $(i = 1,2,3)$, the scalar Cartesian co-ordinates and D_i the scalar components of $\mathbf{D}$, then in (3) expanded the mixed terms $\partial D_i/\partial R_j$, $(i \neq j)$, are zero since the straining is normal in the co-ordinate directions. Thus (3) written with $\mathbf{e}_i$ as unit vectors in the co-ordinate directions gives

$$\vec{\varphi} = \sum_i \left(1 - \frac{\partial D_i}{\partial R_i}\right)^2 \mathbf{e}_i\mathbf{e}_i. \tag{4}$$

This is self-conjugate, so that for pure normal straining (2) represents a central quadric[3], usually an ellipsoid, when R° is unity in particular. Thus a unit sphere in the undeformed body becomes an ellipsoid in the deformed body. Writing r_i for the cosine of the angle between $\mathbf{R}$ and co-ordinate axis R_i and substituting (4) in (2) gives

$$\left(\frac{R^\circ}{R}\right)^2 = \sum_i (r_i)^2 \left(1 - \frac{\partial D_i}{\partial R_i}\right)^2 = 1 + \sum_i (r_i)^2 \left[-2\,\frac{\partial D_i}{\partial R_i} + \left(\frac{\partial D_i}{\partial R_i}\right)^2\right]. \tag{5}$$

Filon would have taken

$$\frac{\partial D_i}{\partial R_i} - \tfrac{1}{2}\left(\frac{\partial D_i}{\partial R_i}\right)^2 \tag{6}$$

as the finite strain component in the direction of R_i for this particular case of normal straining.

However, defining *'true' strain*[4] as *linewise relative displacement per unit length in the deformed body* gives

$$R^\circ = R\,(1 - e_R). \tag{7}$$

Take R in direction $\mathbf{e}_i$ so that e_R becomes e_{ii}, and substitute (7) in (5). Note that then r_i is unity, whereas r_j, $(j \neq i)$, are zero. Then (7) substituted in (5) gives

$$1 - 2e_{ii} + (e_{ii})^2 = 1 - 2\,\frac{\partial D_i}{\partial R_i} + \left(\frac{\partial D_i}{\partial R_i}\right)^2. \tag{8}$$

Comparison of each side of (8) shows that

$$e_{ii} = \frac{\partial D_i}{\partial R_i}, \tag{9}$$

consistent with the definition of true strain. Thus (9) linear in displacement gradient is sufficient to analyse this finite straining. The complicated expression (6) usually taken as a 'finite strain component' is clearly unnecessary and merely occurs in defining the strain quadric in (2), and should not be given further physical significance. Indeed, Cauchy, in 1827[1], derived (5) but did not attempt to call such as (6) finite strain components.

Re-arrange (1) and write it similarly to (2),

$$\mathbf{R}^\circ \cdot \vec{\varphi}^\circ \cdot \mathbf{R}^\circ = (R)^2. \tag{10}$$

This is the inverse strain quadric when R is unity. A unit sphere in the deformed body was an ellipsoid, for example, in the undeformed body. From this follows Saint-Venant's expression with r_i° for the

direction cosine of $\mathbf{R}^\circ$ and co-ordinates referring to the initial position of the current point,

$$\left(\frac{R}{R^\circ}\right)^2 = 1 + \sum_i (r_i^\circ)^2\left[2\,\frac{\partial D_i}{\partial R_i} + \left(\frac{\partial D_i}{\partial R_i}\right)^2\right]. \quad (11)$$

Green derived this in 1839, but, as Pearson remarks[1], unlike Saint-Venant he did not attempt to interpret the expressions as physical strain components. Using Cauchy's nominal strain definition gives results analogous to (6), (8) and (9). Again it is clear that the non-linear 'finite strain' expressions should not be interpreted physically beyond their occurrence in the inverse strain quadric.

The argument has been illustrated here with the very simple case of pure normal straining parallel to the co-ordinate axes, but the reader can satisfy himself of its general truth by using my heterogeneous strain expressions[5], when the material about the typical point has rotated during the deformation.

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Allotropic Transformations in Titanium

IT has been reported[1,2] that pure titanium metal, prepared by the dissociation of titanium tetraiodide[3], undergoes an allotropic change in the temperature range 860–900° C. Titanium has a hexagonal close-packed structure below 860° C. and a body-centred cubic structure above 900° C. A careful examination of this transformation-range in titanium has been carried out. It now appears that there are two distinct transformations, one at 864° C. and another at 900° C., and that a third allotropic modification of titanium is stable between these temperatures.

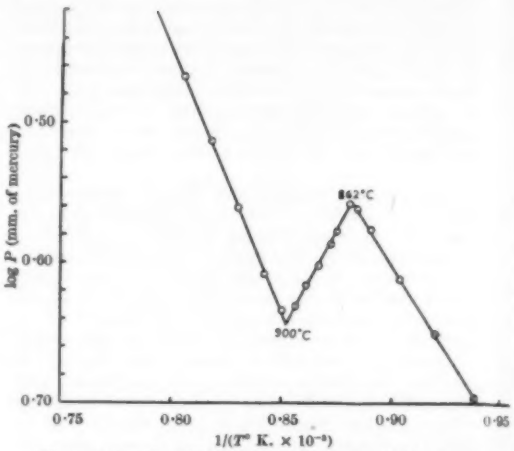
A small quantity of hydrogen (0·02 atomic per cent) was taken into solution in a sample of titanium, the purity of which was better than 99·9 per cent. On heating the titanium in a vessel of small constant volume, an equilibrium hydrogen pressure was set up, and the change in this equilibrium pressure with temperature was measured.

The heat of solution of molecular hydrogen Q in the metal is given by the equation

$$\frac{d(\ln p)}{d(1/T)} = \frac{Q}{R},$$

where p is the hydrogen equilibrium pressure, T the absolute temperature, and R the gas constant. Since the heat of solution is substantially independent of temperature over any temperature-range in which the metal does not undergo a transformation, it follows that in any such region ln p should be a linear function of $1/T$. The accompanying curve shows the experimentally determined relationship between these two quantities.

It would appear from these results that the transformation of α-titanium, which is stable below 860° C., to β-titanium, known to be stable above 900° C., is not simple. In the temperature range 864–900° C., a structure appears which has a positive heat



The variation of equilibrium hydrogen pressure with temperature for a solution of 0·02 atomic per cent hydrogen in 99·9 per cent titanium metal

of solution of hydrogen, as opposed to the negative heats of solution of both α- and β-titanium.

In order to ascertain the effect of hydrogen on the temperatures at which the discontinuities in the ln p versus $1/T$ curve occur, samples of titanium containing increasing amounts of hydrogen were examined. Up to 0·1 atomic per cent, the hydrogen appeared to have little effect on the temperature at which the discontinuities occurred.

If an isothermal α–β transformation in titanium had been broadened out into an (α + β) region by the presence of impurities, it would have been expected that the heat of solution in this region would have assumed values intermediate between that of α-titanium (− 11,030 cal./gm. mol. of hydrogen) and β-titanium (− 16,950 cal./gm. mol. of hydrogen). In the temperature range 864–900° C., however, the titanium has a heat of solution of (+ 13,550 cal./gm. mol. of hydrogen).

It is expected that experiments now in progress will throw further light on this phenomenon.

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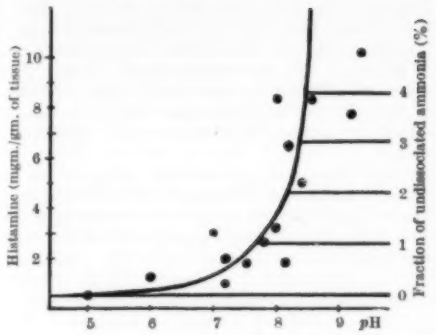
Release of Histamine by Ammonia

HISTAMINE is released from tissues in anaphylaxis, by trypsin, peptones, snake poisons, curare and diamidines. Garan[1] has shown that ammonia vapour liberates histamine from guinea pigs' lungs. The following experiments show that histamine is quantitatively released from striated muscle in a solution of ammonium chloride, but that the effect is entirely dependent on pH, suggesting that it is produced by the free base.

Rat diaphragm was immersed in Ringer's solution at 37° in which sodium chloride was replaced by isosmotic ammonium chloride, and the pH was suitably



adjusted. The diaphragm was kept in this solution for 20 minutes. At the end of this period the tissue was extracted and both extract and solution were assayed biologically for histamine, using the isolated intestine of the guinea pig as test object. Since alkaline ammonium chloride solution depresses the response of the guinea pig's gut to histamine, it was always added in equivalent amount to the standard histamine solutions. The accompanying graph shows that histamine release is a function of *p*H and that it is proportional to the fraction of undissociated ammonia present in the solution. In twenty minutes 50 per cent of the total histamine contained in muscle may thus be released, and if the experiment is further prolonged all the histamine is released. In this respect ammonia differs from *d*-tubocurarine, which releases only about 70 per cent of histamine contained in the muscle[2]. Solutions of potassium chloride and of sodium chloride at the same *p*H release no histamine. These results show that the simplest amine can release histamine, provided that it is present as the undissociated base which can penetrate the cell membrane.

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A Method for Studying the Chemistry of Cacao Fermentation

In the preparation of cacao beans for marketing, it is the normal practice to heap the fresh beans in boxes, so that their covering of mucilaginous pulp can be broken down through the action of yeasts and acetic acid bacteria. The technique has been described by Knapp[1]. During the fermentation the beans are killed. They change in texture. Various chemical constituents are altered, destroyed, synthesized, exuded and absorbed. The process is exceedingly complex and little understood.

It was thought that the technique of paper chromatography[2], which has recently been applied to sugars[3,4], acids[5] and anthocyanin pigments[6], might be a useful aid in following the alterations in the more labile components of the bean during fermentations of varied character.

Attention was first directed to the pulp. The sugars present have previously been merely reported as 'sucrose' and 'glucose' without identification. It was readily shown by chromatography of the fresh pulp juice, using phenol and butyl alcohol as solvents, that glucose, fructose and sucrose are present. Changes in the sugars can be followed continually during the fermentation by the quantitative chromatographic technique[7,8]. No raffinose was detected in spite of the report by Brill[9] that a raffinase is present in large quantity in fresh pulp.

In a similar manner, and using butyl alcohol saturated with formic acid[5] or ethyl acetate – acetic acid as solvents, it was confirmed that the only free acid in the pulp is citric acid, as reported by Hardy[10].

Glutamic acid, aspartic acid, and asparagine were the most prevalent amino-acids in the pulp, and accounted for most of the small nitrogen content, as shown by two-dimensional chromatograms[11].

The alterations in the colouring matters and tannin-like components of the bean can also be followed by the chromatographic technique.

While an extraction with boiling water followed by 40 per cent aqueous acetone is necessary for maximum extraction of tannins[12], it was found that the various constituents could be extracted in the cold with 1 per cent hydrochloric acid. Such extracts were of sufficient concentration to give well-defined spots on the chromatograms (*vide infra*) of the same nature as those obtained by acetone extraction but much better defined. After trial of various solvents commonly used in paper chromatography, the most useful was found to be amyl alcohol – acetic acid (amyl alcohol 4, acetic acid 1, water 5). One bean was found ample for analysis. A 1 per cent hydrochloric acid extract of the bean is used, and after allowing the solvent to run 12–15 hr. the papers are removed and examined in visible and ultra-violet light both while still moist and after allowing to dry. They are then sprayed with saturated sodium carbonate and, after drying, re-examined under visible and ultra-violet light. The following preliminary results may be quoted.

In all the many fresh heat-killed (2 min. at 100° C.) beans of the Forestero variety (purple anthocyanin pigmented) studied, five well-defined spots have been obtained, as shown in the accompanying table.

Spot No.	R_F	Colour of spots: Before Na_2CO_3 spray, Day-light	Before Na_2CO_3 spray, U.-v. light	After Na_2CO_3 spray, Day-light	After Na_2CO_3 spray, U.-v. light	Type of substance
1	0·00	Red	Brown	Brown	Brown	Anthocyanin Leuco-anthocyanin
2	0·08	Red	Brown	Blue	Brown	Anthocyanin
3	0·16	Red	Brown	Blue	Brown	Anthocyanin
4	0·29	—	Purple	—	Green	Leuco-anthocyanin
5	0·42	—	—	Orange	Brown	Catechin

The rate of movement of the spots (R_F values[2]) varies to some extent; but the spots are readily recognized by the colour reactions noted in the table. Other faint and indefinite spots were detected in some samples, but those referred to in the table were invariably present in fresh Forestero beans from many different pods. They are readily recognized and stand out well from the streaky brown background formed on spraying with sodium carbonate, a background which is probably due to tannins.

To determine the nature of the different constituents, 100 drops of a 1 per cent hydrochloric acid extract of Forestero cacao were chromatographed simultaneously, and after development the strips containing the individual spots were cut out and re-extracted with 1 per cent hydrochloric acid. The extracts were examined by the method of Robinson[13].

Spot No. 1. This pigment was present in very small quantity and gave only a faint pink extract. Its distribution between amyl alcohol and water before and after saturation with salt indicated it to be a diglycoside[13]. On boiling for 30 sec. with a ½-vol. concentrated hydrochloric acid, the aglycone was liberated. This was shown by the methods of Robinson to be cyanidin itself. After removal of the cyanidin with amyl alcohol, the colourless solution gave a very bright red colour on further boiling for 15 min., showing that a leuco-anthocyanin was also present. The aglycone was again cyanidin.

Spot No. 2. This pigment gave a deep red extract, and was hydrolysed to cyanidin; it had a distribution indicating it to be a cyanidin pentoseglycoside[13].

Spot No. 3. This pigment, very similar to the above, was hydrolysed to the same aglycone, and had a distribution corresponding to a cyanidin-monoglycoside[13].

Robinson[14], before the introduction of a method of separation as above, described the anthocyanin present in cacao as cyanidin-3-glycoside.

Spot No. 4. The colourless extract, on boiling with concentrated hydrochloric acid for 15 min., or better with methyl alcohol hydrochloric acid, gave a bright red solution of cyanidin, showing it to contain a leuco-anthocyanin.

Spot No. 5. The colourless extract turned bright orange in alkali, green with ferric chloride, and gave a black spot on spraying with ammoniacal silver nitrate. It had an identical R_F value to a sample of cacao catechin[15], prepared from the same batch of cacao.

It will be seen that three anthocyanins and two leuco-anthocyanins are present, all with the same aglycone, cyanidin, as well as the very similar substance l-epicatechin. That the aglycones were, indeed, all identical was confirmed by chromatography. It was necessary to use amyl alcohol equilibrated with 2*N* hydrochloric acid, since the cyanidin rapidly faded in the usual solvent of less acidity[16].

Beans of the Criollo (non-pigmented) variety give the same spots, except that the anthocyanins are absent. The leuco-anthocyanins are present in much greater quantity in these beans.

During a commercial fermentation of Forestero beans which had been in progress for six days, reaching a maximum temperature of 50° C., the only soluble constituents which appeared to be affected to any extent were the anthocyanins. Sample lots of twelve beans were taken daily for analysis during the fermentation; the cyanidin monoglycoside was not eliminated until the 90th hour, whereas the other two pigments had disappeared by the 45th hour (that is, shortly after the death of the bean). However, in beans which had not only been fermented but also sun-dried, none of the above constituents could be detected. On the other hand, when minced beans were allowed to autolyse in air as done by Humphries[17], the anthocyanins were not attacked, whereas the leuco-anthocyanins and catechin disappeared.

Investigations are proceeding along these lines, and it is thought that the method of chromatography will be found extremely useful in following the changes during pure-culture and sterile 'fermentations' of cacao beans.

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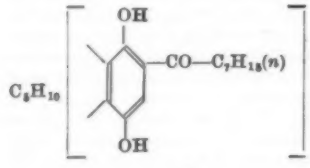
Structure of Flavoglaucin and Auroglaucin

Flavoglaucin, $C_{19}H_{28}O_3$, m.p. 109–110°, and auroglaucin, $C_{19}H_{22}O_3$, m.p. 152–153°, are two pigments, yellow and red respectively, isolated by Raistrick and his collaborators[1] from *Aspergillus glaucus*, and later found by A. Quilico and L. Panizzi[2] in the mycelium of *Aspergillus echinulatus*, where they are accompanied by a neutral colourless substance, $C_{22}H_{35}O_2N_3$ (echinulin)[3]. On the basis of detailed chemical investigations by Robinson, Raistrick, Todd, Cruickshank and others[4–6], structures like (I) and (II) were ascribed to the pigments, the position and the structure of the chain (or chains) present in the residue C_8H_{19} (which contains a double bond) still being undetermined. The existence of the group $(n)C_7H_{15}CO$ was inferred from the fact that *n*-octoic acid was obtained from (I) on oxidation with hydrogen peroxide and sodium hydroxide (by Dakin's reaction); the easy formation of a Schiff's base and phenylhydrazone derivatives both from (I) and (II) points to the presence of a free *ortho* position close to the carbonyl chain. The quinol structure was demonstrated by the absorption



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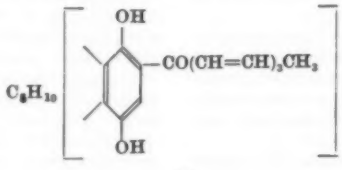
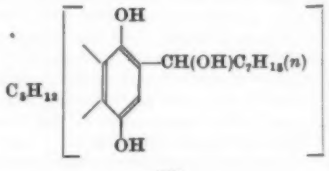
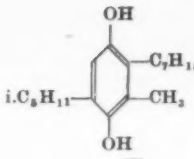


II



III

spectrum in the ultra-violet of tetrahydroflavoglaucin (III) dimethyl ether. As dihydroflavoglaucin, $C_{19}H_{30}O_3$, proved to be identical with octohydroauroglaucin, the two pigments can differ only by the existence of three double bonds in the C_8 side-chain, as formulæ (I) and (II) indicate.



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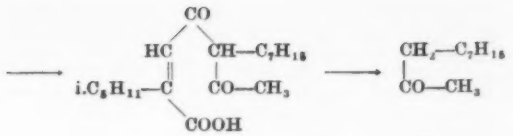
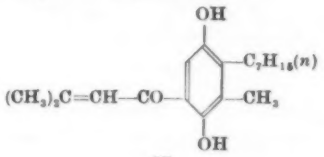
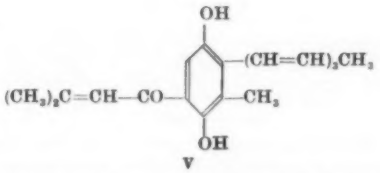


X

Our researches, although confirming the general correctness of the above investigations, have demonstrated that flavoglaucin and auroglaucin possess the structures respectively of 2-*n*-heptyl, 3-methyl, 5-*iso*pentenoylquinol (IV) and 2-*n*-heptatrienyl, 3-methyl, 5-*iso*pentenoylquinol (V):

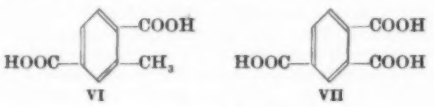


IV

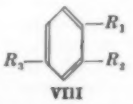


V

On hydrogenation with Raney nickel, flavoglaucin is converted into a cyclic glycol, $C_{19}H_{38}O_2$, which, on distillation with phosphorus pentoxide, yields a diolefin, $C_{19}H_{36}$, reducible with platinum or Raney nickel to the corresponding cyclohexane derivative, $C_{19}H_{38}$. Dehydrogenation of the latter with selenium at 320–340° leads to a benzene hydrocarbon, $C_{19}H_{32}$, from which methylterephthalic acid (VI) and trimellitic acid (VII) have been obtained on oxidation with nitric acid and alkaline potassium permanganate respectively. Three side-chains, R_1, R_2 and R_3 (VIII), must then be present in flavoglaucin in the 2, 3, 5 positions, of which R_2 is a methyl.



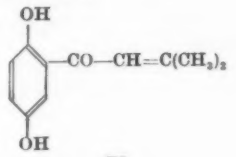
VI VII



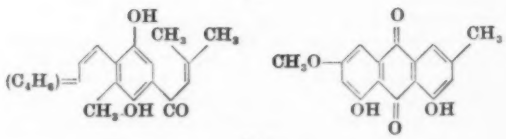
VIII

As tetrahydrodeoxyflavoglaucin (IX), $C_{19}H_{32}O_2$, where —CO— has been reduced to $—CH_2—$, on oxidation with hydrogen peroxide and sodium hydroxide yields *n*-octoic acid (as flavoglaucin does) and methyl,*n*-octylketone (X), R_1 cannot be *n*-octoyl, but must be *n*-heptyl, $-C_7H_{15}$, directly bound to the nucleus. (*n*-Octylquinol, synthesized by us, gave *n*-nonoic acid on oxidation with hydrogen peroxide and sodium hydroxide, as expected.) The fact that the ketone, $CH_3COC_8H_{17}$, was obtained is further evidence for $—CH_2$ being in the *ortho* position relative to $-C_7H_{15}$, as shown by the following scheme:

R_2 must possess five carbon atoms, and contains both the carbonyl group and the double bond; as flavoglaucin on oxidation with potassium permanganate gives acetone and α-hydroxy*iso*butyric acid, R_2 must be $(CH_3)_2C{=}CH—CO—$. *Iso*pentenoyl quinol (XI) methylether, synthesized by us, shows a close resemblance to flavoglaucin both in colour and chemical behaviour.



XI



XII

As confirmation of the quinol structure of (I), oxidation with alcoholic ferric chloride of (IX) yields a yellow quinone, readily reduced to the original substance by $N_2H_4.H_2O$. Comparison of the formulæ for auroglaucin and physcion (XII)[4] shows close structural relations between quinol and anthraquinone pigments of *Aspergillus glaucus*.

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Politecnico di Milano.
Dec. 29.

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A Method for Determining the Ratio of the Michaelis Constants of an Enzyme with Respect to Two Substrates

During some recent work, which will be described elsewhere, it was of interest to determine the Michaelis constants of succinic dehydrogenase with respect to succinic acid and succinic $\alpha - D_2$, $\alpha' - D_2$ acid (tetradeuterosuccinic acid). A number of determinations, carried out by the methods of Lineweaver and Burk[1], appeared to reveal a slight difference between the Michaelis constants of the enzyme with respect to these two substrates. It was, however, desirable to obtain confirmation of this apparent difference by

an independent method. The method evolved is described here since it seems to be generally applicable to problems of this type.

The principle of the method is to study the rates of reaction of a system composed of the enzyme and a mixture of the two substrates in various proportions. The substrates compete for the active centres of the enzyme, and the amount of each substrate which undergoes transformation depends not only on its relative concentration, but also on the relative affinity of the enzyme for each of the two substrates. The conditions under which these experiments were carried out (manometric measurement of oxygen consumption) excluded the possibility of measuring the rates of reaction of each of the two substrates independently; the observed rates of reaction were the summed rates of reaction of the two compounds in the mixture. In order to interpret such data an equation was derived from the Michaelis – Menten theory as follows.

Let us assume a system in which two substrates, S and S', compete for a small quantity of an enzyme:

$$E + S + S' \rightleftharpoons ES + ES' \rightarrow E + P + P'.$$

Now let x and x' be the initial concentrations of substrates S and S'; x_t be the constant total initial concentration of the two substrates ($= x + x'$); v and v' be the rates of disappearance of substrates S and S'; v_t be the total rate of disappearance of the two substrates ($= v + v'$); V and V' be the 'maximum velocities' of reactions of substrates S and S'; K_m and K_m' be the Michaelis constants of the enzyme with respect to substrates S and S'.

The standard expression for the velocity of an enzyme reaction in the presence of a competing substance I (the concentration of which is i, and Michaelis constant, K_i) is

$$v = \frac{Vx}{x + K_m(1 + i/K_i)}$$

(see, for example, Haldane[3]). The velocity of reaction of substrate S in a mixture with the competing substrate S' can therefore be represented as

$$v = \frac{Vx}{x + K_m(1 + x'/K_m')}.$$

Similarly, the velocity of reaction of substrate S' in the mixture can be represented as

$$v' = \frac{V'x'}{x' + K_m'(1 + x/K_m)}.$$

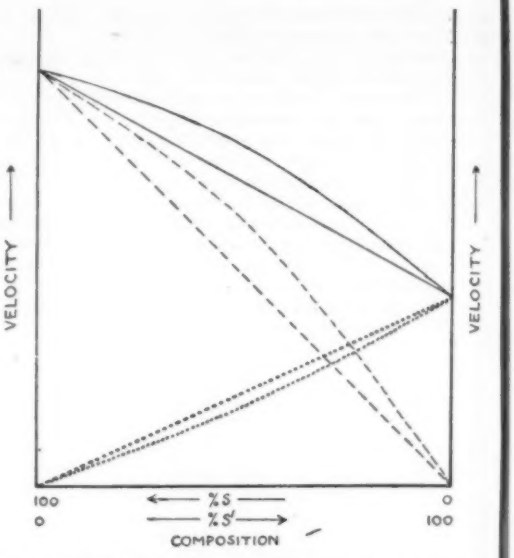
The total observed velocity of reaction of the mixture is therefore the sum of these two expressions; that is,

$$v_t = \frac{Vx}{x + K_m(1 + x'/K_m')} + \frac{V'x'}{x' + K_m'(1 + x/K_m)}.$$

If the Michaelis constants of the enzyme with respect to the two substrates are different (it is assumed in this case that $K_m < K_m'$), the plots of v, v' and v_t against composition of the mixture are in the form of curves, as shown in the accompanying graph (it is assumed that $V > V'$). Should the Michaelis constants of the enzyme with respect to the two substrates be equal (that is, $K_m = K_m'$) the equation simplifies to the form

$$v_t = \frac{Vx}{K_m + x_t} + \frac{V'x'}{K_m + x_t},$$

and it is found that v, v' and v_t become linear functions of composition, as shown in the graph. (If



Variation of reaction-rate with composition of a mixture of two substrates in cases of equal and unequal Michaelis constants: ———, total rate of reaction (v_t); – – – –, rate of reaction of S (v); . . . . . rate of reaction of S' (v'). Curved lines, when $K_m < K_m'$; straight lines, when $K_m = K_m'$

it is further assumed that $V = V'$, the equation reduces to the original Michaelis equation, as would be expected since the two substrates are now virtually the same.)

In order, therefore, to determine whether an enzyme has identical or different Michaelis constants with respect to two substrates, it is necessary to study the rates of reaction of a series of mixtures of the two substrates, and to plot rate of reaction against composition of the mixture. If this plot is a curve, the Michaelis constants are different; if it is linear they are identical.

Moreover, it is possible to construct a curve, relating the variation of reaction-rate with composition, by substituting experimentally determined values of K_m and K_m' and formal values of V and V' (obtained by substituting the appropriate data in the original Michaelis equation) in the mixed-substrate equation. The degree of correspondence of this curve with the experimentally determined curve provides a check on the correctness of the experimentally determined values of K_m and K_m'.

Since it is the ratio of the Michaelis constants which determines the degree of departure from linearity of the curve, it is not possible to calculate K_m and K_m' from competitive mixed-substrate experiments of this type. It is, however, possible to obtain a value for the ratio by fitting a curve to the experimental points. For example, the K_m values of succinic dehydrogenase with respect to succinic acid and tetradeuterosuccinic acid were found to be $1{\cdot}2 \times 10^{-3}\ M$ and $2{\cdot}2 \times 10^{-3}\ M$ respectively, giving a ratio K_m^D/K_m^H of 1·83. By means of competitive mixed-substrate experiments, a series of points relating v_t with composition were obtained. Using the mixed-substrate equation, it was found that the curve which best fitted the data corresponded to a ratio K_m^D/K_m^H of 1·45. Owing to the errors which attend the determination of Michaelis constants by

measurement of rates of oxygen consumption at progressively decreasing substrate concentrations, it is considered that the latter value for the ratio K_m^D/K_m^H, obtained by an indirect method in which the enzyme reaction is always proceeding at its practical maximum velocity, is more nearly correct.

This work was carried out while I was in receipt of a personal grant from the Medical Research Council, which I gratefully acknowledge.

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Electrokinetic Potential of Barium Sulphate

The electrokinetic potential of barium sulphate has been investigated repeatedly; but the results of various authors show no agreement either with respect to the sign of the potential or its magnitude. Most investigators, except Michaelis and Dolan[1], find the solid negatively charged, and Ruyssen[2] has recently reiterated his opinion that the pure salt has a negative charge in water. We have subjected this problem to a careful investigation[3] and found that precipitated as well as recrystallized barium sulphate, ignited immediately before establishing contact with water, has a well-reproducible positive potential against its saturated solution in water and in alcohol–water mixtures, provided that traces of surface-active impurities, which may originate from rubber joints and are not always absent even in double-distilled water, are rigorously excluded. An all-glass streaming potential apparatus and a procedure of freeing distilled water from traces of surface-active impurities (distillation from acid potassium permanganate solution) has been described recently[3]. The barium sulphate crystals retain a constant positive potential on ageing in water, irrespective of the quantity of water that is streamed through the plug. However, when ordinary distilled water, or water that was in contact with rubber or filter paper (cf. Ruyssen's experimental method[4]), is streamed through a plug of barium sulphate crystals, the positive potential decreases and changes to negative. Even leaving the crystals with water in a vessel that is open to the laboratory air for several days may cause a decrease of the positive potential. Obviously surface-active impurities are strongly adsorbed on the surface of the barium sulphate crystals. However, the original positive potential is restored on ignition of the crystals to 500–700° C., or on treatment with hot concentrated nitric acid, whereby the impurities are destroyed.

Although ignition is the most convenient method for obtaining barium sulphate crystals which show reproducible positive potentials, it is by no means essential. Precipitated barium sulphate has a positive potential without previous ignition provided solutions freed from surface-active impurities are used in its preparation, and this potential remains unchanged on ageing in the streaming potential cell.

In view of these findings, it appears to be probable that the negative potentials obtained by several workers[2,4,5] are due to the presence of surface-active impurities which are difficult to eliminate completely. This is suggested also by the poor reproducibility of the results of some investigators. It is worth considering that the effect of such impurities in water will be different from that in alcohol–water mixtures.

We made similar observations with other sparingly soluble sulphates (lead and strontium sulphates). It would appear that the role of surface-active impurities requires careful attention in electrokinetic work, particularly with positively charged surfaces.

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Evolution of the Giraffe

According to Darwin the long neck of the giraffe is the result of natural selection acting through the animal's tree-feeding habit. He wrote: "the individuals which were the highest browsers and were able during dearths to reach even an inch or two above the others will often have been preserved"[1].

There are serious objections to this argument.

(1) During dearths, severe and frequent enough for natural selection to operate through leaf-shortage, the recurrent wastage of young giraffes would threaten the species with extinction.

(2) Under such extreme conditions of dearth the grass-eating African ungulates would also have been so short of food that it is difficult to see why more of them did not develop the leaf-eating habit and the excessively long neck.

(3) Bull giraffes tend to be several inches taller than the cows, so that during each dearth males would be naturally selected at the expense of the females—another factor likely to lead to rapid extinction.

An alternative theory free from these criticisms has occurred to me.

The most extraordinary anatomical feature of the giraffe is not the length of the neck but the length of the forelegs.

This extreme length of leg gives the animal a huge stride, so that in spite of a rather slow galloping rhythm it can move at speeds up to 32 m.p.h.[2].

The giraffe is actively preyed upon by lions and leopards. It is reasonable, therefore, to explain the excessive length of its forelegs as the effect of natural selection acting continually through the hunter–hunted relationship, as in the case of hoofed animals generally.

Now, like other ruminants, the giraffe requires a plentiful supply of water. The development of an increasing shoulder height, therefore, necessitated the development of a means of getting the head down to the water-level. Horses and antelopes solved this problem by the simultaneous development of a proportionately long neck. I believe the giraffe solved it in the same way. That the neck has elongated

to a degree only just sufficient to keep pace with the increasing length of the legs is suggested by the fact that the giraffe has to splay its forelimbs awkwardly to drink.

In this light, natural selection would seem to have operated continually in favour of increasing length of neck instead of intermittently during discontinuous periods of drought as necessitated by Darwin's theory.

Further, it seems to me that the leaf-eating habit of the giraffe is a concomitant of the development of the long neck and not the cause of it. It would seem reasonable to suppose that the ancestors of the giraffe were grass-eaters, and that with the lengthening of the neck a new source of food became available, resulting in a change of feeding habit. This contention is supported by the fact that giraffes eat grass if leaves are not available, and they thrive on hay in zoological gardens.

It may be argued that the giraffe's closest living relative, the okapi, is a leaf-eater, although its neck is no longer than that of a horse. The okapi, however, lives in dense forests where it has no option but to eat leaves.

I am indebted to Dr. Julian Huxley for valuable criticism of these views.

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Daily Express,
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An Aerobic Medium for Fungus Growth Studies

THE aerobic nature of mushroom composts plays an essential part in the production of good mushroom crops, so that it is desirable, in laboratory growth-experiments on mushroom mycelium, to use an aerobic medium of known composition in which growth measurements can be made. The only fully aerobic medium of this nature in general use, so far as I am aware, is milled filter paper[1,2,3]. Unfortunately, this material loses its aerobic qualities when only a small amount of nutrient solution has been absorbed on it. A medium based on milled transparent cellulose shavings, dyed black to enable mycelial growth to be observed, has now been found to be more satisfactory, and is prepared as follows.

Boil cellulose film trimmings 'PT' (British Cellophane Co.) with a 0·5 per cent solution of carbide black *E* (Clayton Aniline Co.) for 1–2 hr. until a good dye is obtained. Squeeze out the dye liquor, wash twice with tap water, and soak the clippings in 0·5 *N* hydrochloric acid for 1 hr. Drain and wash with tap water until the *p*H rises to about 4, then with distilled water until free from sulphate and chloride. Dry thoroughly at 50–70° C. and immediately grind to pass the desired mesh screen. For general work, the 1-mm. screen may be used. A batch of material prepared in this way had 0·09 per cent ash, containing mainly calcium with some iron and aluminium, traces of magnesium and manganese and no copper or nickel. Mix with nutrient solution at the rate of 100 ml. of solution to 100 gm. of medium and pack lightly into 5 in. × ¾ in. test-tubes.

Preliminary experiments with the mycelium of the cultivated white mushroom *Psalliota campestris* using 4 per cent malt nutrient solution gave excellent agreement in growth-rate between replicates when the tubes were inoculated with a ¼-in. layer of the cellulose medium, in which the fungus had previously been grown from pure culture. The initial linear growth-rate is independent of the density of the medium within the range 0·7–1·7 gm. of moist medium per cm. tube-length (variations in density are obtained by milling through different screens). As the bottom of the tube is approached the growth-rate decreases more rapidly in the denser than in the lighter media. Differences in aeration rather than in the rates of diffusion of nutrients are thought to be responsible for this effect.

It is hoped to use this technique for the study of trace-element and growth-substance requirements of this organism, for comparing soluble and insoluble nutrients, and for further work on the influence of the grading of the medium on mycelial growth.

I wish to thank the Director of Research and the directors of the Mushroom Research Association, Ltd., for permission to publish this note.

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Poisoning of Farm Animals by the Marsh Ragwort (*Senecio aquaticus* Huds.)

ELEVEN *Senecio* spp. have been reported to occur in the British Isles[1], but only a few of these contaminate pasture land to any appreciable extent. The common ragwort (*Senecio jacobæa* Linn.) has been incriminated in Britain[2,3,4] and elsewhere[5,6] as the cause of a fatal poisoning when eaten by livestock, known generally as 'seneciosis'. This condition, in cattle and horses, may either take a rapid fatal course with the liver showing acute necrosis, or a more lingering chronic type with liver cirrhosis as the main lesion.

Into one knackery in Pembrokeshire, during the period September 1947–August 1948, there was an intake of fifty-one animals diagnosed as having died of seneciosis. The predominant species infesting the pasture in this area is *Senecio jacobæa* Linn., and eradication trials using selective weed-killers have so far yielded promising results[7]. In Carmarthenshire, seneciosis, mainly in horses, has occurred on farms where the land is heavily infested with the marsh ragwort (*Senecio aquaticus* Huds.); there was no clear published evidence of the toxicity of this species[8]. Quantities of the plant were collected at the flowering stage from fields in the area, and also from cured hay on the actual farms where losses had occurred. By the following procedure a crystalline *Senecio* alkaloid was isolated from *S. aquaticus* from both sources.

The plants were dried at 100° C., milled, and the powder continuously extracted with ethanol. On evaporation of the ethanol fraction, the residue containing the total alkaloids, with much chlorophyll and dark resinous matter, was triturated with 2 per cent hydrochloric acid, and the clear brown acid-soluble fraction separated from tarry residues. Pig-

ments were removed from this solution by ether and chloroform extraction, before making alkaline with ammonia to liberate the free alkaloids, which were extracted with chloroform. Evaporation of the solvent gave a crystalline residue (yield 0·04 per cent of plant dry-weight); three recrystallizations from ethanol gave white lustrous octahedral crystals of constant m.p. 220° C. (decomp.). It was lævorotatory, $[\alpha]_D^{15°\,C.} = -83°$ (1 per cent chloroform). Micro-analysis gave C, 64·1; H, 7·1; N, 4·4; $C_{18}H_{25}NO_5$ requires C, 64·5; H, 7·5; N, 4·2. The picrate crystallized in yellow needles from methanol, m.p. 182° C., and on micro-analysis gave C, 50·97; H, 4·91; N, 9·95; $C_{18}H_{25}NO_5.C_6H_3N_3O_7$ requires C, 51·06; H, 4·96; N, 9·92.

This alkaloid differs in its constants and derivatives from those already isolated from other *Senecio* spp. and listed by de Waal[9] (also Henry[10]); to indicate its origin we propose to call it 'aquaticine'. Further work on its chemical nature and relationship to the other *Senecio* alkaloids await the collection of an adequate bulk of material.

Feeding experiments using rats amply demonstrated the toxic nature of *S. aquaticus*; inclusion of the dried and milled plant to the extent of 20–40 per cent of the ration caused rats to become unthrifty, with death within three weeks, the animals showing lesions typical of seneciosis. Dosages of 3–7 mgm. of pure aquaticine acetate injected subcutaneously invariably killed rats of 60–70 gm. weight within forty-eight hours. At death, the carcases were jaundiced, and showed intestinal hæmorrhages, capillary congestion of the lungs, vascular changes in the liver varying from congestion of the blood vessels to marked hæmorrhagic areas with resulting necrosis; the kidneys showed changes, varying from congestion of glomeruli and œdema into Bowman's capsule, to necroses of the convoluted tubules.

Aquaticine inhibits the movements of the isolated rabbit intestine, the effect being quite marked at a dilution of 1/50,000.

These results indicate that the marsh ragwort, *Senecio aquaticus*, is probably as toxic to livestock as some of the other species of *Senecio* are known to be.

Thanks are due to Dr. P. Thomas for identification of botanical species. This work has arisen from a survey of causes of death and incidence of disease in farm animals, carried out by one of us (E. T. Rees Evans) and supported by the Agricultural Research Council, to which body acknowledgment is made. One of us (W. Charles Evans) thanks the Royal Society for a grant.

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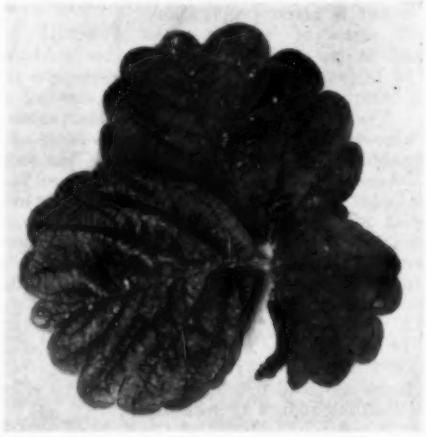
Stem Eelworm in Strawberries

An interesting case has occurred in Scotland of strawberry 'eelworm disease' in which the causal organism was *Anguillulina dipsaci*, the stem eelworm.

A stock of certified Huxley Giant plants was bought by a grower in the Lothians in the spring of 1948 and planted in two different fields situated within a few hundred yards of each other. One field had previously been under an ordinary farm rotation and the plants here remained quite healthy. The other field, however, had been under cauliflowers in 1947 and beans for the three preceding seasons. In June, Mr. T. Robertson, of the Department of Agriculture, in inspecting the crop, noticed that the runner plants which had taken root were curiously crumpled in appearance, many of the parent plants showing the same symptom to a slighter degree. The leaves were malformed, as shown in the accompanying reproduction, crumpled and sharply reflexed, while the apices were flattened and the indentations fewer and larger than normal for this variety.



The symptoms were at first thought to be due to aphis damage in the early bud stage, or to attack by the usual strawberry eelworm, *Aphelenchoides fragariæ*. Laboratory examination, however, failed to confirm this; but the stem eelworm, *Anguillulina dipsaci*, was found actively reproducing in the buds. No other species of eelworm was present. It was known that *A. dipsaci* could attack beans, and it seemed likely that after three successive crops, the soil population was high, resulting in the infestation of the strawberries. This point has now been confirmed by Mr. J. B. Goodey (personal communication), who has successfully transferred infection from samples of the above strawberries to oat plants, the strain of *A. dipsaci* concerned attacking beans and oats. It is important to note that in this case infestation was contracted from the soil, not, as is usually the case with *Aphelenchoides fragariæ*, carried in infected runners. The runners from such a crop are, of course, now infested, and if used for planting would bring about infestation of the soil with stem eelworm, a much greater potential danger to other crops than *Aph. fragariæ*, which is confined to strawberries.

Although there is no previous published account of this pest on strawberry in Scotland, official files at East Craigs record a similar infection on Sir J.

Paxton plants sent from Melrose in 1938, the same year in which Hodson[1] published the only account of its occurrence in England.

I am indebted to Mr. J. B. Goodey for his invaluable assistance and advice.

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Fossil Burrows from the Pre-Cambrian Ajibik Quartzite of Michigan

THE 'hard rock' below the pre-Cambrian unconformity has been searched for fossils the world over, but the results are still few and frequently indistinct. Fossils, ranging from real to very dubious, have been described from the pre-Cambrian of Canada, Finland, India and the United States. The present note announces a new find from Michigan. A more complete report is under preparation.

Small slabs of ripple-marked quartzite were collected in the vicinity of the Ropes gold-mine, north of Ishpeming, Michigan. The specimens show gently curving sinuous marks on the bedding surfaces. The marks are tentatively interpreted as fossil burrows, particularly interesting because of the well-established Middle Huronian age of the formation. Some of the burrows measured were up to 2 ft. in length; but most of the traces are a few inches long and 3–5 mm. wide. They are slightly raised, non-annulate and very gently to broadly sinuous. Transverse thin sections cut through the marks show that they are not simple trails such as are produced by recent millipedes, gastropods, or by floating objects. Instead they appear to be uniform, sinuous ropes of sand, closely following the uneven bedding surfaces, but separated from them by a thin film of ferruginous material much the same as the coating of the bedding planes themselves.

I am completely ignorant of the type of organism which made the burrows. It would appear that the animal was digging on the surface or at a slight depth, following the old bedding planes. Such behaviour is not illogical, for a scavenger might very well find sufficient food on the old surface. The sand-filling of the burrows may or may not have passed through the digestive tract of the creature, although the complete absence of annulate structure and the broad

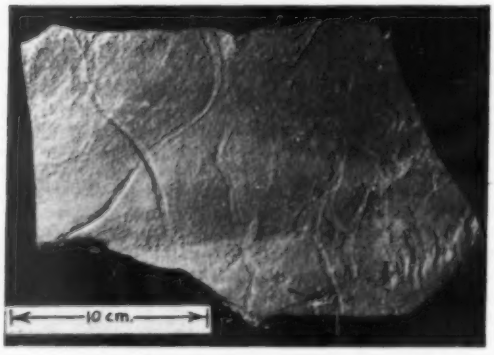

Fig. 1. Stratigraphically lower surface of a quartzite slab bearing the casts of several burrows

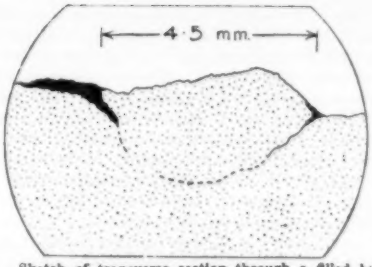

Fig. 2. Sketch of transverse section through a filled burrow. The sand filling is identical with the surrounding sand

curves of the traces would seem to indicate that the movement was fairly rapid.

The Ajibik quartzite is a very hard, moderately pure, massive rock, grading upward into the Siamo slate, which in turn is overlain conformably by the Negaunee iron formation. Helium age-determinations[1] made on magnetite from mines in this formation indicate an age of *c.* $1{,}200 \times 10^6$ years. The mines are only a few miles distant from the Ajibik locality.

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D.D.T. as a Residual Insecticide against *Anopheles maculipennis*

THE article by Muirhead-Thomson[1] on D.D.T. and *Anopheles gambiæ* adds support to my belief that the same conclusions may apply to *A. maculipennis* varieties. During service in Italy in 1944 and 1945, I was concerned with the effect of D.D.T. in areas where *A. maculipennis* var. *labranchiæ* and var. *typicus* were the common varieties. Mosquito catches, and other observations, made in areas where 'domestic' resting places had been treated with 5 per cent D.D.T. in kerosene, suggested that control was not so complete as at first appeared. None of this evidence was conclusive, but it did indicate that the fall in mosquito numbers seen in houses treated with D.D.T. did not represent a comparable reduction in the total mosquito population of the area. It suggested to me a repellent rather than a lethal action of D.D.T.

On the basis of such observations as I made, I wrote a Service memorandum in September 1945. This pointed out that our knowledge of the reactions of mosquitoes to D.D.T. was incomplete, suggested that outside resting-places might be utilized by mosquitoes in areas treated with D.D.T., and emphasized that the kill was questionable. I suggested a series of experiments to test these points, but Service conditions did not permit of their completion. Yet Muirhead-Thomson's findings with *A. gambiæ*, arrived at independently, support my earlier observations; with this additional evidence, I consider that the value of D.D.T. as a malaria control measure is also open to doubt in areas where *A. maculipennis* var. *labranchiæ* is the vector.

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FIBROUS PROTEINS

Rubber-like Properties of Hair Keratin

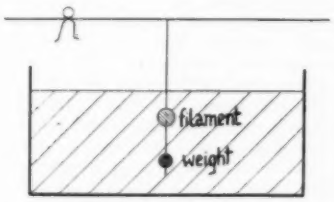
IT follows from the classical work of Joule[1] that the restoring force of stretched rubber is due to thermal motion. Meyer, v. Susich and Valk [2] showed for rubber at 100–300 per cent extension that the force at constant extension is proportional to the absolute temperature, and that therefore the free energy change $(\partial G/\partial l)_T$ at infinitesimal deformation equals the entropy term $-T(\partial S/\partial l)_T$. The same authors advanced the theory that the force is due to thermal motions of the oriented segments of the stretched chains, which tend to bring back the segments to their previous more probable random orientation. Thermo-elastic investigations showed this to be true also for other elastomers, for example, gutta percha, polyphosphornitrilic chloride, heat-contracted collagen[3] and elastic ligaments[3].

In contrast to this, the restoring force of stretched keratin (wool or hair) is attributed by Astbury[4] and Woods[5] to attractive forces which favour a definite folded configuration of the keratin protein chains. According to Bull[6] and Woods[5], the thermo-elastic behaviour of wool and hair seems to confirm this hypothesis. Woods found that the entropy of wool increases on stretching up to 20 per cent elongation, and a similar result with human hair has been reported by Bull. According to these authors, the elastic force in this region cannot therefore be attributed to the existence of a less random arrangement in the stretched state. However, soft rubber exhibits the same phenomenon at elongations of less than 12 per cent, and the explanation was given simultaneously be Gee[7] and by Meyer and van der Wyk[8]. The observed increase in entropy on stretching is simply due to the increase in volume (and in the so-called 'free volume') of the elastomer, which provides more freedom of oscillation for the segments. The entropy change on elongation is thus composed of two terms: one positive, due to the increase in free volume of the segments; the other negative, due to their less random arrangement. At a certain elongation (12 per cent for rubber, 22 per cent for hair and 20 per cent for wool) the two terms are equal and the entropy change becomes consequently zero. At greater elongations $(\partial S/\partial l)_T$ always becomes negative. The true rubber-like thermo-elastic properties are thus disguised at smaller elongation. It seems thus that the differences between hair, wool and rubber are only of a secondary nature, and that it is merely the overlapping of the effects which varies from substance to substance.

In order to eliminate the volume effect, Meyer and van der Wyk[8] investigated the thermo-elastic behaviour of rubber at small shearing deformations which involve no dilatation. They found 'ideal' rubber-elastic behaviour for soft rubber even at the smallest deformations. Similar results have been obtained by Mooney[9] with polychloroprene, butyl rubber and 'Thiokol' under torsion.

We thought it of interest to investigate the thermo-elastic behaviour of hair under a small torsion. Owing to the experimental difficulty of working with fine hairs, we used hairs from the tail of an Indian elephant. These hairs are 1–1·5 mm. thick and exhibit no rubber-like properties in the natural state. Rubber-like properties appear, however, if the hair is left in the presence of swelling agents such as alkali, formic acid or aqueous 70 per cent thioglycollic acid, the latter being the most effective. This reaction is exactly the same as the plasticizing of potential elastomers such as polyvinylchloride by suitable means ('plastifiers'). The thermo-elastic behaviour of elephant hair and of filaments of other substances was investigated by means of the following experimental arrangement, which will be described in detail elsewhere.

Threads 12 cm. long and of about 0·3 cm. diameter of vulcanized rubber, plastified polyvinylchloride (Geon polyvinylchloride 100 gm., dibutylphthalate 100 cm.³, oleic acid 3 cm.³, lead stearate 2 gm.) and swollen elephant hair are held horizontally between two clamps, one of which is rotatable. Passing through the centre of the filaments is a thin rigid wire to the upper end of which is attached a wire serving as a balance beam; a compensating weight is attached to the end below.



A torque is applied by rotation of one clamp; the vertical (0) position of the wire is then restored by a rider. The moment of the rider is thus equal to the torque. The torque τ (at constant deformation) is read at different temperatures; as is shown by the accompanying table, it is for all substances investigated proportional to T within the limits of error

$$\left(\frac{\tau_1 - \tau_2}{\tau} \cdot \frac{T_1}{T_1 - T_2} \sim 1\right).$$

	T_1	T_2	τ_1	τ_2	$\frac{\tau_1-\tau_2}{\tau}\cdot\frac{T_1}{T_1-T_2}$
Soft rubber	323	292	55	50	0·95
	333	291	69	60	1·04
Polyvinylchloride	321	286	160	146	0·80
	329	287	236	205	1·03
Elephant hair	321	282	258	230	0·90
"	282	306	230	251	1·07
"	321	298	244	230	0·8

Moreover, the torsion moduli $\varepsilon = \frac{\tau \cdot 2 \cdot l}{\alpha \cdot \pi \cdot r^4}$ (l is length, r is radius of the thread) of the three threads are very similar: 5×10^6 dyne cm.$^{-2}$ for soft rubber, 6×10^6 dyne cm.$^{-2}$ for plasticized polyvinylchloride and 8×10^6 dyne cm.$^{-2}$ for swollen elephant hair.

It is thus shown that plastified hair behaves in exactly the same way with respect to entropy and energy change at small torsions as do true elastomers or plastified potential elastomers. We conclude, therefore, that the elastic restoring force of swollen hair keratin is of the same nature as that of true elastomers.

We are indebted to Mr. Revillod, director of the Museum of Natural History of the City of Geneva, for supplying us with elephant hair, and to Mr. M.

Gordon, of the Dunlop Rubber Co., for preparing a thread of plasticized polyvinylchloride.

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Meyer and Haselbach's attempt to explain away the negative temperature gradient of the load on wool fibres stretched in water, even if successful, would not alter the principal conclusion to be drawn from my experimental results, that the elasticity of normal keratin is, in the end, due primarily to internal energy, with the entropy taking a subsidiary and distinctly minor role. I should say that its essentially energetic character is sufficient difference from the ideal rubber-like behaviour to justify the claim that normal keratin is not rubber-like; Meyer's use of the term "disguise" is thus merely a euphemism and can only obscure the issue.

To meet Meyer on his own ground, however, it is legitimate to ask whether his hypothetical *increase* in volume does, in fact, occur when keratin is stretched; it is not enough to say that it must do so because it does in rubber, when the issue is whether or not keratin is rubber-like. It is generally accepted, and my own experience supports this, that the changes in volume of wet wool fibres, when they are stretched, are small. I do not know of any measurements precise enough to give a definite answer to the question as to whether the volume, if it changes at all, increases or decreases, and I should be unwilling to accept an argument based on elementary elasticity theory for two reasons: that the fibres are not isotropic, and that they are swollen. This latter means that we must bear in mind the possibility of changes in water content as the load and temperature are varied, and a consequence of any change in water content might be a change in volume. In this connexion I should like to direct attention to some recent results of White and Stam[1], which appear to be in better agreement with the idea of a decrease in volume on stretching. White and Stam studied the swelling in water vapour of human hair under tension, and came to the conclusion that the (volume) swelling decreases as the tension increases; it is true that their procedure was to load the dry fibre and then allow it to swell, so that they may not have reached the same end-point as would be attained by loading wet fibres (in fact, the size of the effect observed by them is such that it is quite certain that they did not); but their results suggest that any volume changes which may have occurred in my experiments may well have been in the opposite sense to that required by Meyer. His theory cannot, therefore, be accepted without some experimental support.

Meyer and Haselbach's experiments on the torsional rigidity do not provide this. Keratin is an oriented, cross-linked structure; by suitable treatments (some of them I have noted elsewhere[2]) it is possible to break the cross-links, destroy the orientation, and, by swelling, to isolate the polypeptide chains to such a degree that rubber-like properties ensue; this, in fact, is what happens in their experiment. Thioglycollic acid causes not only disulphide breakdown but also, as a consequence, swelling of such an order that one must expect a considerable, if not complete, destruction of birefringence and crystallinity. Under such conditions the appearance of rubber-like properties is not surprising; the keratin must be so far modified, however, as to make the results of little value in helping to solve the problem of the elastic mechanism in normal fibres. Some idea of the efficiency of the "disguise" which Meyer claims to remove by the action of thioglycollic acid is provided by a comparison of his observed modulus of rigidity (8×10^6 dynes/cm.^{2}) with Speakman's value[3] for untreated wool fibres in water ($\sim 1{\cdot}3 \times 10^9$ dynes/cm.^{2}). If it is really necessary to weaken keratin as much as this in order to make the rubberiness apparent, we may be satisfied that the "disguise" is well-nigh perfect.

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Classification of Fibrous Proteins

Fibrous proteins have been classified by Astbury[1] into two groups, the keratin–myosin–fibrinogen group and the collagen group. The first group exhibits 'long-range' elasticity, which is attributed to attractive forces tending to establish a special folding of the protein chains in the contracted state. Against this classification, however, serious arguments may be advanced. As has been shown in my preceding communication, swollen hair keratin exhibits true rubber-like elasticity; the restoring force is due to thermal movements of the chain segments, as is shown by the increase in entropy on restoration of the original state. In all elastomers, including hair, this latter effect may be disguised in certain circumstances: for example, at small deformations under stress, as a result of the increase in volume; at temperatures below the softening point, by the cohesive forces; and in the case of cross-linked polymers by the inhibition at high elongations of the free displacement of segments which is a condition of true rubber-like behaviour. Not only hair but also many other elastomers, for example, vulcanized filled rubber, acetylcellulose[2] and polyvinylacetate films[3], exhibit non-ideal rubber elastic behaviour. Long-range elasticity is by no means limited to the keratin-myosin-fibrinogen group, for all fibrous proteins may be brought into the rubber-like state by heat treatment (collagen) or by plasticization. Even silk fibroin, which apparently is not rubber-like, exhibits long-range elasticity when it is taken directly from the glands of the silkworm[4].

According to Astbury, the proteins of the keratin group give two kinds of X-ray diffraction pattern, α and β, the former characterized by an identity period of $\sim 5{\cdot}1$ A., the latter by a period of ~ 7 A. In the β-form, the chains are supposed to be fully extended in the zigzag form, which had been pre-

viously established by Meyer and Mark[5] for the case of natural silk. Silk, however, although exhibiting the β-diagram and belonging, therefore, to the keratin group, never occurs in the α-form; and myosin, which also belongs to this group, may crystallize under certain conditions according to Lotmar and Picken[6], and exhibit a fibre pattern with the same identity period (5·65 A.) as collagen ($2 \times 2{\cdot}85 = 5{\cdot}7$ A.). Collagen, on the other hand, gives, according to Clark[7], an addition compound with sodium hydroxide with identity period 6·5 A., which is not far from the value of 7 A. for β-keratin. It seems, therefore, that the occurrence of proteins in two modifications is not limited to one group and is analogous to the similar behaviour of other fibrillar polymers, for example, gutta-percha and cellulose and its derivatives.

While it must be acknowledged that Astbury's theories have stimulated experimental work and thus proved their usefulness, in the light of the evidence presented above his protein classification ought now to be abandoned.

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For the thermo-elastic data which I have used in discussions of the nature of the long-range elasticity of keratin I am indebted to my colleague, H. J. Woods, and his views on the significance of the particular experiment described by Meyer and Haselbach are accordingly set out above. To Woods's comments, with which I agree, I may be permitted to add the following. Even had the experiment been carried out on *normal* hair, and even supposing Meyer and Haselbach's interpretation for the small torsions used to be correct, I still do not see how one can argue therefrom that similar considerations hold necessarily for the whole of the great elastic range of keratin. In the first few per cent extension, the X-ray diagrams show that the α-form is stretched, but after that the α-form gradually disappears and the dominating feature is its reversible transition to the β-form. Moreover, at no stage is there any structural analogy with unstretched rubber, which consists of a higgledy-piggledy arrangement of chain-molecules, whereas unstretched hairs are oriented and birefringent and give X-ray *fibre diagrams* without any need to stretch them first.

Again, putting aside all this, I confess even then to failure to understand Meyer's reasoning on the interpretation of the elastic properties of high polymers in general. As I see it, the free energy equation allots part of the restoring force to internal energy effects of all sorts, both intra- and intermolecular, and part to entropy effects; and it is possible to estimate the two parts separately, as Woods and Bull have done in their thermo-elastic studies of keratin and other fibres. The test with rubber shows that the entropy factor is large compared with the internal energy factor, while a corresponding test with normal animal hairs gives a result the other way round—that is all. To infer from this that the driving force of elastic recovery is really always due to entropy effects, but that we cannot always detect it because it is disguised by the driving force due to internal energy effects, is a step I am unable to follow.

To come now to my X-ray classification of the fibrous proteins, which Meyer puts forward reasons for abandoning. Since, let it be emphasized, it is primarily an X-ray classification (though we have, of course, attempted, and I believe successfully, to correlate it with characteristic elastic properties), Meyer's purely X-ray criticisms should be considered first. To these I would reply as follows:

(1) In view of the very great differences in amino-acid composition between silk fibroin and members of the keratin myosin–epidermis-fibrinogen group which give rise to both α- and β-forms, there is no known reason why fibroin should necessarily give rise to an α-form in addition to the β-form in which it has so far been found.

(2) So far as I am aware, it has never been demonstrated that the structure photographed by Lotmar and Picken, which Meyer claims to have "the same identity period (5·65 A.) as collagen ($2 \times 2{\cdot}85 = 5{\cdot}7$ A.)", was actually a form of myosin. The diffraction diagram in question was given by a specimen that admittedly had been kept in a tin box for something like a year, and the only other record of such a diagram is one by Herzog in 1926. On the other hand, numerous X-ray photographs have been taken of what the biochemist recognizes as myosin (or myosin plus some actin), both inside and outside muscle, and they have always been of the α-type for the unstretched state.

(3) Clark's postulated addition compound of collagen with sodium hydroxide was obtained after swelling the fibres for 24 hours in 0·4 *M* sodium hydroxide and then drying under tension, *but without washing*, whereupon the weight of sodium hydroxide taken up (at this concentration) was found to be about half the original weight of the collagen. The X-ray photograph showed the collagen diagram with a sharper pattern superimposed on it, as though crystalline material had been trapped within and oriented by the fibre structure—and according to my experience in a variety of cases, such a thing can happen fairly easily. The mean residue weight of the postulated 1 : 1 addition compound, calculated from the density of the air-dried composite material on the assumption of a mean residue length of 3·25 A., came to the very high value of 170 (cf. 96 for gelatin); and, moreover, the corresponding identity period of a similarly prepared 'addition compound' with potassium hydroxide was found to be not 3·25 A. but 3·78 A. In the light of these considerations, the substance of which I communicated by letter to Prof. Clark himself in 1940, I suggest that we cannot accept without very serious misgivings Meyer's argument that collagen gives "an addition compound with sodium hydroxide with identity period 6·5 A., which is not far from the value 7 A. for β-keratin".

Altogether, I am in no way convinced that my X-ray classification of the fibrous proteins should now be abandoned. As regards Meyer's other criticisms of it based on elasticity studies, of course I agree, and it is well known, that all fibrous proteins can be endowed with more or less rubber-like properties by suitable heat treatment, swelling, and other means which have the effect of enhancing the entropy factor at the expense of the internal energy

factor. But the point at issue is the interpretation of the elastic properties of the normal fibres, and particularly normal keratin. Finally, to avoid another possible source of misunderstanding, it is perhaps worth stressing that we have never sought to explain the elastic properties of all protein fibres in terms of the α–β transformation.

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CONTROL OF PIGMENT MIGRATION IN CRUSTACEANS

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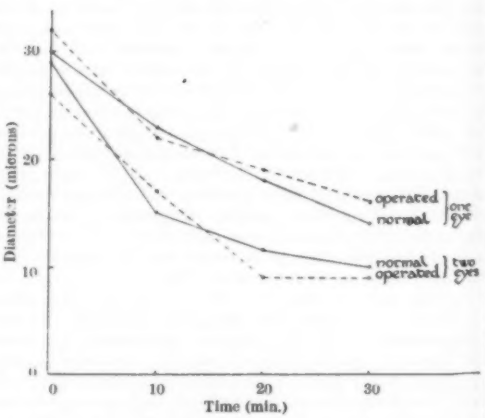
THE discovery that the movements of pigment in the eyes and in the chromatophores of crustaceans may be influenced by hormones has been followed by investigations in recent years of various aspects of the control, such as the number of hormones involved, the sources of the hormones and whether they are, in fact, the sole agents responsible for the control of the normal pigment migrations in the species studied. Recently published results have indicated that the control is more complex than had previously been supposed.

Evidence from anatomy[1] and physiology[2] first pointed to the sinus gland lying in or near the eye stalk as an important source of chemical pigment activators; but recent observations reveal that there may also be sources of pigment-activating hormones elsewhere. It is generally accepted that whole eye-stalk extracts concentrate the dark pigments in the integument of Macruran decapods; but it has recently been shown that extracts of the sinus gland alone, freed from surrounding eye-stalk tissues, dispersed white pigments in the light-reflecting chromatophores of *Cambarus* and *Crangon*. As a result of these and other injection experiments, Brown and his collaborators have implied that the hormone concentrating the white pigment in crustaceans may be formed elsewhere than in the sinus gland[3]. If this is so, then the removal of the sinus gland should interfere with the normal movements of the dark pigments but not those of the white pigments. I believe this to be the case in the shrimp *Leander adspersus*.

When this shrimp is placed on an illuminated white background, the dark pigments contained in chromatophores of the integument concentrate, whereas white pigments in the light-reflecting chromatophores disperse. On an illuminated black background the positions of the pigments are reversed. After removal of the eyes and their stalks, both white and dark pigments disperse. An injection of eye-stalk extracts into eyeless animals will concentrate both white and dark pigments, although the response of the latter is more prolonged. An extract was prepared from eye stalks freed from surrounding eye-stalk tissues, and was injected into animals deprived of their eye stalks; in each such experiment the dark pigments concentrated sharply, but the white pigments remained dispersed, even though some animals received concentrated doses (equivalent to four eye stalks). Injection experiments thus indicated that the sinus gland is not the source of the hormone causing concentration of white pigment in *Leander adspersus*.

The sinus gland may be removed without damage to the mechanism of visual perception. The method described by Panouse[4] was employed, and the behaviour of the dark pigments was taken as an indication of the success of removal of the sinus gland. After operation the dark pigments of about half the experimental animals dispersed and remained thus irrespective of the conditions of illumination or of the backgrounds on which the animals were placed. The behaviour of the white pigments in these animals was, however, unaffected by the removal of the sinus gland. On an illuminated white background the white pigment dispersed in the reflecting chromatophores; on an illuminated black background the white pigments migrated inwards in their chromatophores, as in normal animals with intact sinus glands. In *Leander adspersus*, therefore, the dark pigments are controlled by a hormone originating in the sinus gland, but the hormone influencing the white pigments is produced elsewhere.

The control of the crustacean retinal pigments also seems to be more complex than had previously been believed. In 1897 Parker[5] found that, when he illuminated one eye only in *Palæmonetes varians*, the proximal pigment of the illuminated eye became light-adapted, while that of the darkened eye remained in a dark-adapted position. From this experiment Parker concluded that the movements of the proximal pigment were the result of a direct response of the pigment cells to the presence or absence of illumination. His results were supported by those of Castle (1927)[6], but opposed by Bennitt (1924)[7], who demonstrated a physiological interrelationship between the eyes of certain crustaceans. It has since been shown that injections of eye-stalk hormone bring about the light-adaptation of the retinal pigments in certain species[8], although it has been pointed out that the possibility of a direct response of the pigment cells to illumination also cannot be excluded[9]. The effects of removal of the sinus gland in *Cambarus*[10] and in Grapsoid crabs[11] indicates that the proximal retinal pigment can continue its normal responses in the absence of the sinus gland; some experiments which



Movement of white pigment within reflecting chromatophores when *Leander adspersus* is transferred from an illuminated white background to an illuminated black background. The behaviour of the white chromatophores in normal animals is contrasted with that in animals from which sinus glands had been removed. Observations were taken at ten-minute intervals and recorded as the diameter of pigment masses measured in microns; each point represents the mean diameter of single white chromatophores in five animals

[1] Hanstr
[2] Perkin
[3] Brown
[4] Panous
[5] Parker
[6] Castle,
[7] Bennit
[8] Kleinh
[9] Kleinh
[10] Kleinh
[11] Smith,
[12] Kleinh
[13] Welsh,

I have performed during the past few years support this view, and suggest also that the reactions of the distal pigment cells to humoral control may be modified by external conditions of illumination.

In *Leander serratus* and *Leander adspersus*, one eye was covered and the other was illuminated. In all cases (138 experimental animals) the proximal pigment of the illuminated eye moved to the light-adapted position, while that of the covered eye attained a position of partial dark-adaptation, so indicating that the control of the proximal pigment is not a purely humoral one, if, indeed, chemical activators are involved at all. After the removal of the sinus gland, the proximal pigment continued its normal migrations in response to changes of illumination. Kleinholz has recently reported that the proximal pigment in *Astacus* will continue its normal movements in light and darkness, even in eyes which have been severed from the body and thus isolated from the central nervous system and the circulatory system[12]. The injection experiments of Welsh[13], however, suggest that the proximal pigment in *Cambarus* may be influenced by eye-stalk hormones.

The position of the distal pigment also differed in the two eyes when one eye was illuminated and the other was darkened. On a brightly illuminated white background (when the concentration of eye-stalk hormone in the blood is high) the position of the distal retinal pigment in a covered eye was similar to that in an exposed eye; on a black background or under dim illumination (when the concentration of eye-stalk hormone in the blood is low) the degree of proximal migration of the distal pigment was greater in an exposed eye than in a covered one. After removal of the sinus glands, the distal pigment remained in a dark-adapted position, even though the eyes were exposed to brilliant illumination. These results taken together indicate that the distal pigment granules will not move as a direct response to change of illumination, but that the presence or absence of illumination may modify the response of the distal pigment cells to the hormone by which they are activated.

Recent investigations, therefore, show the inadequacy of the view that pigment movements in crustaceans are controlled solely by the agency of hormones produced in the sinus gland of the eye stalk. In *Leander adspersus* the white pigments are not controlled by any hormone produced in the sinus gland. In *Leander serratus* and in *Leander adspersus* the proximal retinal pigment continues its normal movements in the absence of the sinus gland. The distal retinal pigment is apparently influenced by a hormone produced in the sinus gland, but the response of the distal pigment cells to this hormone is modified by external conditions of illumination.

I am indebted to the Challenger Society for financial support of some of the work on which this discussion is based.

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EXAMINATION OF METALS BY OPTICAL METHODS

THE practical application under industrial conditions of experimental methods and techniques developed in the laboratory is of the utmost importance. The industrial worker has his own problems and methods, and is often unaware of advances in the fundamental sciences which might prove of great value to him. Moreover, the fact that a technique has proved of significant value in one field frequently implies that it has application in another. Many problems are recognized to be intractable when existing techniques are used; for these, new techniques must be sought. For such reasons the British Iron and Steel Research Association set up, after the War, a New Techniques Committee, which is under the chairmanship of Mr. E. W. Colbeck, a director of Messrs. Hadfields, Ltd. There are under this committee a number of sub-committees devoted to studying different methods of examining the properties and behaviour of iron and steel. The work of these committees is in part to survey and assess the relevance of existing techniques, in part to develop new techniques, and where necessary to support the fundamental investigations on which any new experimental method must be based. Not the least of their activities is to express an opinion as to whether, indeed, application under industrial conditions is possible.

Such committees are faced directly with the problem of bridging the gap between development in the pure sciences and industrial application of such developments. Publication through the usual channels is invariably at a level which the non-specialist finds extremely difficult to understand. What is required is an opportunity for the specialist to explain and to demonstrate to the industrialist the possibilities and the limitations of his techniques. The limitations of the method are as important as its advantages. Opportunity for demonstration is vital.

The Committee on Optical Methods of the British Iron and Steel Research Association, of which the chairman is Dr. G. K. T. Conn, held on May 9 and 10 at Ashorne Hill, Leamington, a conference to explore the usefulness of certain optical methods in industry. The fact that some hundred and fifty people attended makes it clear that it catered for a very real need. Of these about thirty came from the universities, about forty from research associations and Government laboratories, and about eighty from industry. The topics chosen were considered from the point of view of their application to the study of metallurgical problems. Three subjects were discussed: phase-contrast microscopy; the reflecting microscope and multiple-beam interferometry. Phase-contrast microscopy[1] was developed some years ago and has recently been applied intensively to biological problems[2]. Application to metallurgy seems, however, largely to have been limited to the National Physical Laboratory[3]. Reflecting microscopes have recently been developed[4,5]. These have two great merits: they are achromatic, and they have a significantly greater working distance[6] than the orthodox lens systems. The latter property is of immediate value to metallurgy, particularly in studies at high temperatures. Multiple-beam interferometry[7] offers means of examining surface topography and even structure and deformation with a refinement of detail not readily accessible by other means. The

topics were chosen as representing (*a*) an established technique which merits consideration by metallurgists; (*b*) a new and important variant of an old instrument which has already proved its value; and (*c*) a method the possibilities of which are being explored but which has already provided results of material value.

The conference was opened by Mr. E. W. Colbeck, who welcomed the company and explained the functions of such committees and the purpose of the conference. At the first session, Mr. K. J. Habell, of the National Physical Laboratory, explained the principles of phase-contrast microscopy, and Mr. D. McLean, also of the N.P.L., showed, with a wealth of illustrations, some of the advantages and limitations of the method in metallography. The second session was devoted to the reflecting microscope[4], the construction and behaviour of which was discussed by Mr. R. L. Drew, of the University of Bristol. The metallurgical applications were considered by Mr. K. W. Keohane, also of the University of Bristol. Dr. F. Hekker, of N.V. Optische Industrie "de oude delft", explained the action and demonstrated the commercial instrument marketed by his firm, which, because it uses spherical surfaces and a spherical meniscus correcting lens after the fashion of a Schmidt plate, is remarkably inexpensive. Mr. W. E. Seeds, of King's College, London, described and demonstrated a reflecting microscope of numerical aperture 0·5 using spherical surfaces without correction, and Mr. H. T. Heal, of the Physics Laboratories of the British Iron and Steel Research Association, described a reflecting objective for high-temperature microscopy. The principles of multiple-beam interference[8] were presented and illustrated by Prof. S. Tolansky, of the Royal Holloway College, London. The metallurgical applications of these methods were discussed and demonstrated by Mr. J. Holden and Mr. D. G. Nickols, of the Royal Holloway College, London.

The discussion at all three sessions was lively and showed an acute interest in the possibilities presented. Attention was directed by Mr. H. Morrogh, of the British Cast Iron Research Association, to the merits of using polarized light in microscopy, and Mrs. P. Dunsmuir, of the British Thomson-Houston Co., Ltd., mentioned a very attractive application to etched metallic surfaces of elliptically polarized light. Demonstrations of phase-contrast microscopy were shown by Messrs. Cooke, Troughton and Simms, Ltd., and by Messrs. W. Watson and Sons, Ltd.; of reflecting microscopes by Dr. C. R. Burch and his colleagues of the University of Bristol, by Mr. Seeds, and Dr. Hekker; of multiple-beam interferometry by Mr. Holden. Mr. Habell and Mr. McLean, in addition to showing phase-contrast microscopy, also demonstrated the only Linnik interferometer in Great Britain. Dr. A. F. Hallimond, of the Geological Survey, had a demonstration of his very simple stop-contrast[9], which he explained during the discussion.

There seems little doubt that such a conference serves a very necessary purpose. The benefits can mature only with time, but the interest was undoubted and surprisingly widespread. A brief account such as this cannot hope to do justice to all the aspects considered and all the topics discussed. A more detailed account will be available in due course. It seems clear that two conditions must be fulfilled if such a meeting is to succeed. The number of topics must be limited; it is felt that the restriction to three was undoubtedly successful, ensuring a uniformity of interest in addition to making the best use of the time available. Broadly speaking, application to only one industrial field should be considered; in the present case the application was to metallurgy. If widely varying applications are considered, there is a considerable danger that the discussion will become diffuse.

G. K. T. Conn
G. M. Leak

[1] Zernike, F., *Mon. Not. Roy. Ast. Soc.*, **94**, 377 (1934); *Physica*, **1**, 689 (1934); *Z. tech. Phys.*, **16**, 454 (1935); *Phys. Z.*, **36**, 848 (1935). Burch, C. R., *Mon. Not. Roy. Ast. Soc.*, **94**, 384 (1934). Burch, C. R., and Stock, J. P. P., *J. Sci. Instr.*, **19**, 71 (1942). Martin, L. C., *Nature*, **159**, 837 (1947).
[2] Barer, R., *Quart. J. Mic. Sci.*, **88**, 491 (1948).
[3] Cuckow, F. W., *Nature*, **159**, 639 (1947).
[4] Burch, C. R., *Nature*, **152**, 748 (1943).
[5] Burch, C. R., *Proc. Phys. Soc.*, **59**, 41 and 47 (1947).
[6] Bouwers, A., "Achievements in Optics", 46 (Elsevier, 1946).
[7] Barer, R., *J. Roy. Mic. Soc.* (in the press).
[8] Tolansky, S., "Multiple-beam Interferometry" (Oxford Univ. Press, 1948).
[9] Hallimond, A. F., *Nature*, **157**, 851 (1947).

CARNEGIE INSTITUTION OF WASHINGTON

ANNUAL REPORT FOR 1947–48*

YEAR Book No. 47 of the Carnegie Institution of Washington, covering the year ended June 30, 1948, includes the reports of the executive committee, the auditors and the president, together with the departmental reports and a list of publications for the period November 1, 1947–June 30, 1948. The most interesting feature of the president's report is his observations on the formulation of research programmes, which have been discussed elsewhere (see *Nature*, June 25, p. 969); but his report also emphasizes some of the most important points in the departmental reports.

The investigation of the general magnetic fields of early-type stars at the Mount Wilson Observatory continues to lead to new and unexpected results, and the variations in stellar magnetic fields observed by Dr. H. Babcock imply the presence of tremendous electric potentials, suggesting a possible source for the particles with very high energy found in cosmic rays. The departmental report details the approved plan for joint operation of the Mount Wilson and Palomar Observatories by the Institution and the California Institute of Technology, and includes some account of work on galactic nebulæ and star clouds, extra-galactic nebulæ and photo-electric photometer observations of stellar magnitudes.

In the Geophysical Laboratory new observations on the behaviour of aqueous solutions of silicates under pressure have demonstrated that solution of solids in vapour may occur in notable amounts, and this may represent an important step in some types of mineral deposition. Investigations on the formation of hydrated magnesium silicates and on the phase relations of anhydrous silicate mixtures, such as the system potash–magnesia–alumina–silica, and on the inversion of quartz and the thermal properties of minerals, are also reported.

In the Department of Terrestrial Magnetism the seismic programme for investigating the strength and

* Carnegie Institution of Washington. Year Book No. 47, July 1, 1947—June 30, 1948; with Administrative Reports through December 10, 1948. Pp. 235. (1948.)

structure of the crust of the earth has yielded results indicating that the granitic layer in the region investigated is about 10 km. thick, and that the compressional wave velocity in it is between 6·0 and 6·17 km./sec. Electric surveys over the tops of certain clouds were begun in order to ascertain whether thunderstorms supply electricity to the earth at the rate required to maintain the negative charge and its counterpart, the electric field, which is observed at the surface in all areas where fair weather prevails. Significant progress is being made in improving the resolution of radio echo-sounding methods in ionospheric research, and techniques are being developed for measuring the magnetic field of the earth at high altitudes. Further studies have been made of the nuclei of light elements, and the biophysical programme includes a number of projects using radioactive tracers.

The Division of Plant Biology, focusing its attention on the fundamental processes by which plants synthesize food, has isolated the immediate precursor of chlorophyll, and it is now possible to measure the amount of this protochlorophyll present in leaves. A study of the components of chloroplasts responsible for the evolution of oxygen in photosynthesis has been undertaken, and other investigations reported include the occurrence and properties of chloroplast pigments, chlorella as a source of food and the uronides of leaves. The range-grass programme has further advanced, and an analysis of a long-term study of the ecological genetics of climatic races of *Potentilla gladulosa* has reached publication stage. In the Department of Embryology further progress was made in studying the development of the human body and in elucidating the physiology of reproduction and gestation in higher mammals and man. Advances were made in knowledge of the cyclic changes in the human ovary and in the uterus during the menstrual cycle, and an effective topodynamometer was devised for recording the contractions of the human uterus during labour.

In the Department of Genetics continued research on the organisation of the chromosomes has included histochemical studies using purified crystalline enzymes with various staining procedures, which have provided information concerning the *in situ* localization of nucleic acids and proteins and their affinity for certain dyes. Chemical studies have shown that the ability of ribonuclease to hydrolyse ribonucleic acid is greatly inhibited if desoxyribonucleic acid is present in the digestion mixture. Analysis of the modifying action of near infra-red radiation on X-ray-induced genes and of chromosome alterations in *Drosophila* indicates that the induced breaks are not all of one type. Investigations of the newly arising loci in maize have continued; and other studies have dealt with the action of the genes *a* in the meal moth *Ephestia* and *T* and *Fu* in the mouse, while those on the mutagenic potency of carcinogens and chemically related compounds showed that chromosome breaks may be induced in *Drosophila* by four out of sixteen chemicals tried. The changes in population that occur when two strains of *Escherichia coli* are grown together have been analysed, and a method devised for determining the number of bacteriophage particles present in an infected bacterium at any one stage after infection. Experiments with sonic vibrations are also reported, as well as laboratory studies of individual genes, mouse leukæmia, and the genetic structure of natural populations.

INSTITUTE OF PHYSICS

ANNUAL MEETING

AT the twenty-ninth annual general meeting of the Institute of Physics, held on May 20 at the Playhouse, Buxton, during the convention of the Institute, the following were elected to take office on October 1: *President*, Dr. F. C. Toy; *Vice-President*, Dr. S. Whitehead; *Honorary Treasurer*, Mr. E. R. Davies; *Honorary Secretary*, Dr. B. F. Dudding; *New Ordinary Members of the Board*, Mr. T. C. Keeley and Dr. H. L. Penman. Sir Edward Appleton, principal and vice-chancellor of the University of Edinburgh, was elected an honorary fellow of the Institute.

The twenty-ninth annual report of the Board, covering the work of the Institute during 1948, was presented to the meeting. It records that the Board met six times, and its various committees eighteen times, during the year. The membership in all grades has increased, the total membership reaching the record figure of 3,455. A high standard apparently is required for entry into the fellowship grade, for out of fifty-five applications received during the year more than half were rejected or deferred. A new list of members, subscribers and students, containing up-to-date information concerning their appointments, qualifications and addresses, which is the first complete list since 1938, has been published.

Several technical colleges have applied for official recognition by the Institute as institutions suitable for the training of physicists. These colleges were inspected by representatives of the Institute and of the Ministry of Education, and eight were granted official recognition. A joint conference with the Ministry of Education on problems in the teaching of physics in technical colleges was held in February 1948. An impression of this conference appeared in the October 1948 issue of the *Journal of Scientific Instruments and of Physics in Industry*. The Board has also been concerned with proposals concerning technological education and training in Great Britain, and its report, entitled "The Education and Training of Technologists", which formally dissents from the proposals of the Parliamentary and Scientific Committee, was approved in March and has since been widely distributed.

The Institute has been represented on many joint committees and bodies, including committees of the British Standards Institution, the Royal Society, and the Physical Society. The names of the representatives and of the various bodies are listed in the annual report, and reports of some of the representatives of the Institute are given in an appendix.

Two summer schools, the first in June on the application of theoretical physics to problems of creep in metals, and the second in September on the physics of solids, were held in collaboration with the H. H. Wills Physical Laboratory of the University of Bristol. A third, arranged by the Electron Microscopy Group of the Institute in conjunction with the Board of Extramural Studies of the University of Cambridge, dealt with the fundamental theory of the electron microscope and the methods used in its principal applications.

Not only have the title and size of the *Journal* of the Institute been enlarged in accordance with the decision taken last year (see *Nature*, July 17, 1948, p. 120), but the size of the advisory committee has also been increased to give representation to the

branches and groups of the Institute, and to the Physical Society and its groups. It is recorded, further, that for the first time for many years it has been possible to print sufficient copies to meet the continually increasing circulation. An addition to the "Physics in Industry" series was published during the year, being the papers read at the conference on the measurement of stress and strain held at Manchester in 1946. In accordance with the resolution of the Board to concentrate first on the development of publications, a committee has been set up to advise on the early establishment of a new journal devoted to applied physics, and the publication of educational booklets, a monthly house journal, and further volumes in the "Physics in Industry" series.

Eight of the thirty pages of the annual report are devoted to the activities of the branches and groups of the Institute. These make interesting reading. The Australian branch, in addition to a very successful conference on heat transfer at which thirty-three papers were read, has had several visits from prominent British physicists, including the late Sir Clifford Paterson and Prof. M. L. E. Oliphant. The Indian branch does not appear to have been very active, but the five branches and six subject-groups in Great Britain have held a diversity of discussions, lectures and conferences of very high standard and interest.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Wednesday, July 6

INSTITUTION OF MINING AND METALLURGY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 5 p.m.—Dr. C. H. Desch, F.R.S.: "The Effect of Impurities on the Properties of Metals" (Second Sir Julius Wernher Memorial Lecture).*

Thursday, July 7

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.15 p.m.—Discussion on "Muscular Contraction and Relaxation—their Physical and Chemical Bases" (to be opened by Prof. A. V. Hill, F.R.S.).

Thursday, July 7—Friday, July 8

INSTITUTION OF MINING AND METALLURGY (at the Royal Institution of Chartered Surveyors, 14 Great George Street, London, S.W.1), at 10 a.m. each day.—Symposium on "The Refining of Non-Ferrous Metals".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER to take Biology up to the standard of Intermediate Science, First M.B., etc.—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford (July 9).

LECTURER IN PHYSICS AND PHYSICAL CHEMISTRY at the Birkenhead Technical College—The Director of Education, Education Offices, 63 Hamilton Square, Birkenhead (July 9).

RESEARCH STUDENTSHIP to carry out physiological and clinical investigations into congenital heart disease—The Dean, Guy's Hospital Medical School, London Bridge, London, S.E.1 (July 9).

LECTURER IN THE PHYSICS AND MATHEMATICS DEPARTMENT, to teach up to B.Sc. General Degree standard—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham (July 9).

ASSISTANT LECTURER IN PHYSICS at the Bradford Technical College—The Director of Education, Town Hall, Bradford (July 9).

ASSISTANT LECTURER IN THE DEPARTMENT OF CHEMISTRY to undertake teaching in Physical Chemistry—The Registrar, University College, Hull (July 11).

LECTURER IN GEOGRAPHY, specially for research in cartographic methods—The Secretary, The University, Edinburgh (July 15).

PHYSICIST in the Dominion Physical Laboratory—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (July 15).

ASSISTANT AGRICULTURAL ECONOMIST—The Registrar, The University, Bristol 8 (July 16).

FISHERIES OFFICER IN THE DEPARTMENT OF AGRICULTURE—The Secretary to the High Commissioner for Southern Rhodesia, Rhodesia House, 429 Strand, London, W.C.2 (July 22).

LECTURER OR ASSISTANT LECTURER IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Sheffield (July 23).

DEMONSTRATOR IN BOTANY—The Registrar, The University, Leeds 2 (July 25).

SCIENTIST (Grade I or Grade II) on Coal Survey H.Q. staff, for work involving the collation of scientific data relating to coal seams and carrying considerable executive responsibility—The National Coal Board, Establishments (General Branch), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/146 (July 28).

SENIOR LECTURER IN ELECTRICAL ENGINEERING—The Secretary, Royal Technical College, Glasgow (July 30).

ENGINEER II in the Inspectorate of Armaments, Ministry of Supply—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.137/49A (July 30).

CURATOR OF THE DEPARTMENT OF NATURAL HISTORY in the Museum, Kelvingrove, Glasgow—The Town Clerk, City Chambers, Glasgow, endorsed 'Curator of the Department of Natural History' (July 30).

LECTURERS (2) IN ZOOLOGY, one having special reference to Experimental Zoology and the other to Cytology and Protozoology—The Secretary, The University, Edinburgh (July 31).

LECTURER IN PHARMACOLOGY in the Senior Medical School, Dundee—The Secretary, The University, St. Andrews (July 31).

ASSISTANT LECTURER IN MATHEMATICS AND ENGINEERING—The Registrar, The University, Manchester 13 (August 8).

ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Reading (August 15).

LECTURER IN BIOCHEMISTRY in the Department of Physiology—The Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1 (August 15).

CHAIR OF CHEMISTRY at Victoria University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 31).

SCIENTIFIC OFFICER (with honours degree in Zoology) to join a team studying Plankton Zoology in relation to the Fisheries—The Officer in Charge, Oceanographic Laboratory, 23 Sandport Street, Leith, Edinburgh 6.

LECTURER IN BIOLOGY, to take classes up to Final Degree standard in Zoology—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1.

LECTURER IN CHEMISTRY—The Registrar, Municipal College, Portsmouth.

BIOCHEMICAL TECHNICIAN—The Dean, St. Thomas's Hospital Medical School, London, S.E.1.

ASSISTANT SUPERINTENDENT to be responsible for the operation of all the production units in a large factory consisting of nuclear piles and associated chemical plants—The Staff Section, Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington.

LABORATORY TECHNICIAN—The Administrative Officer, National Institute for Medical Research, Hampstead, London, N.W.3.

SENIOR GEOLOGIST FOR THE MINES DEPARTMENT, Adelaide—The Agent-General for South Australia, South Australia House, Marble Arch, London, W.1.

ASSISTANT CHEMIST IN THE SCIENTIFIC RESEARCH DEPARTMENT, Glasgow—The Scientific Research Manager, Railway Executive, London Midland Region, Euston Station, London, N.W.1.

YOUNG CHAIR OF TECHNICAL CHEMISTRY—The Secretary, Royal Technical College, Glasgow.

DEMONSTRATOR IN PHARMACEUTICS—The Registrar, The University, Nottingham.

ASSISTANT LECTURER AND DEMONSTRATOR IN THE DEPARTMENT OF CHEMISTRY—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

PATHOLOGICAL LABORATORY TECHNICIAN—The Administrative Officer, Kingston General Hospital, Hull.

POST-GRADUATE STUDENTSHIPS (6) in preparation for research in Soil Science in the Colonial Empire—The Under-Secretary of State, Colonial Office (Research Department), Sanctuary Buildings, Great Smith Street, London, S.W.1.

SENIOR ASSISTANT FOR APPLIED PHYSICS—The Registrar, College of Technology and Commerce, The Newarke, Leicester.

ASSISTANT (with university degree or equivalent technical qualification) to work in the Information Section—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Geological Survey and Museum. A Prospector's Handbook to Radioactive Mineral Deposits. Pp. 28. (London: H.M. Stationery Office, 1949.) 6*d*. net. [105

New Education. No. 1, May 1949. Pp. 18. (Edinburgh: New Education Press, 1949.) 1*s*. 3*d*. [115

Anti-Locust Bulletin 4: Aircraft Spraying against the Desert Locust (*Schistocerca gregaria* Forskål) in Kenya, 1945. By Dr. D. L. Gunn, F/Lt. J. F. Graham, F/Lt. E. C. Jacques, F/O. F. C. Perry, F/Lt. W. G. Seymour, F/Lt. T. M. Telford, J. Ward, E. N. Wright and D. Yeo. Pp. 121+19 plates. (London: Anti-Locust Research Centre, British Museum (Natural History), 1948.) 12*s*. [115

Department of Scientific and Industrial Research. Report of the Chemistry Research Board, with Report of the Director of the Chemical Research Laboratory for the Year 1947. Pp. iv+91. (London: H.M. Stationery Office, 1949.) 2*s*. net. [115

Catalogues

Cambridge Unipivot Galvanometers for D.C. Measurements. (Sheet No. 284.) Pp. 4. Cambridge Unipivot Galvanometers for A.C. Measurements. (Sheet No. 285.) Pp. 4. (London: Cambridge Instrument Co., Ltd., 1949.)

Biological Stains and Reagents. (List X.) Pp. 28. (London: George T. Gurr, 136 New King's Road, S.W.6, 1949.)

Some Industrial Uses of PVC. Pp. 6. (London: BX Plastics, Ltd., 1949.)